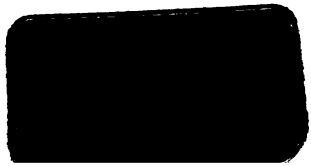
Laboratory Manual of General Chemistry

Williams



LABORATORY MANUAL

OF

GENERAL CHEMISTRY.

INCLUDING

DIRECTIONS FOR PERFORMING ONE HUNDRED OF THE MORE IMPORTANT EXPERIMENTS IN GENERAL CHEMISTRY AND METAL ANALYSIS, WITH BLANKS AND A MODEL FOR THE SAME, LABORATORY RULES AND SUGGESTIONS, AND TABLES OF ELEMENTS, COMPOUNDS, SOLUTIONS, APPARATUS, AND CHEMICALS.

PREPARED FOR USE WITH ANY TEXT-BOOK OF CHEMISTRY; SPECIALLY ADAPTED TO ACCOMPANY "INTRODUCTION TO CHEMICAL SCIENCE."

BY

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APPARATUS FOR EACH LOCKER.

[APPARATUS AND CHEMICALS CAN BE OBTAINED OF DR. A. P. GAGE, BOSTON. "INTRODUCTION TO CHEMICAL SCIENCE" IS PUBLISHED BY GINN & CO., BOSTON].

2 horseradish (or olive) bottles, and corks to fit.
1 soda bottle.
2 pieces window glass (3 in. sq.).
2 pieces glass tubing (20 in. long, $\frac{1}{4}$ in. diam.).
1 glass stirring-rod.
1 glass funnel (3 in., 60°).
1 piece ignition tubing (12 in. long, $\frac{1}{2}$ in. diam.).
1 porcelain evaporating dish (3 in. wide).
1 asbestus paper, or wire gauze (3 in. sq.).
1 iron (or tin) plate (5 or 6 in. diam.).
1 pair forceps.
1 three-cornered file.
1 round file ($\frac{3}{16}$ in.).
1 copper wire (15 in. long, No. 20).
6 test-tubes, and corks to fit.
1 wooden test-tube holder.
1 thistle-tube.

APPARATUS FOR GENERAL USE.

Flasks (200^{cc}).
Bunsen burners.
Rubber tubing (18 in. long, $\frac{1}{4}$ in. diam., inside).
Iron ring-stands.
Reagent bottles (250 and 500^{cc}).
Metric rulers (30^{cm} long).
Graduates (25^{cc} and 200^{cc}).
Scales with metric weights (1–100^{g}).
Pneumatic troughs.
Glass tubing ($\frac{1}{4}$ in. outside diam.).
Glass tubing ($\frac{3}{4}$ in. diam.).
Hessian crucibles (50 or 100^{cc}).
Beakers (25 or 50^{cc} and 1000^{cc}).
Lead trays (5 or 6^{cm} sq., 1 deep).
Mortars and pestles.
Fine wire gauze (No. 50 or 60, 4 in. sq.).
Platinum wire (No. 23).
Blow-pipes.
Bricks.

If all the pupils of a class work in the laboratory at the same time and on the same experiment, each should be supplied with a set of apparatus; if they work in divisions of say 10, 10 sets will be enough. This also applies to the "Apparatus for Each Locker."

CHEMICALS.

Estimates for a Class of Twenty.

Acetic acid	2 lb.	Litmus paper	2 ft.
Alcohol	2 lb.	Magnesium chloride	2 oz.
Alum	4 oz.	Magnesium ribbon	2 ft.
Ammonium carbonate	2 oz.	Manganese chloride	2 oz.
Ammonium chloride	1 lb.	Manganese dioxide	1 lb.
Ammonium hydrate	4 lb.	Magnesium sulphate	1 oz.
Ammonium nitrate	1 lb.	Marble	2 lb
Ammonium oxalate	2 oz.	Mercuric nitrate	2 oz.
Ammonium sulphate	4 oz.	Mercurous nitrate	2 oz.
Antimony (metallic)	¼ oz.	Molasses	1 pt.
Antimony chloride	2 oz.	Naphtha	1 lb.
Arsenic (metallic)	¼ oz.	Nitric acid	7 lb.
Arsenic teroxide	½ oz.	Nickel chloride	1 oz.
Barium chloride	3 oz.	Phosphorus	¼ lb.
Barium nitrate	1 oz.	Picture wire	7 ft.
Beeswax	3 oz.	Potassium (metallic)	⅛ oz.
Bi-carbonate of soda	2 oz.	Potassium bi-chromate	4 oz.
Bismuth nitrate	2 oz.	Potassium bromide	2 oz.
Bleaching-powder	½ lb.	Potassium chlorate	2 lb.
Bone-black	½ lb.	Potassium chromate	1 oz.
Brimstone	1½ lb.	Potassium cyanide	1 oz.
Cadmium nitrate	2 oz.	Potassium ferrocyanide	2 oz.
Calcium chloride	2 oz.	Potassium hydrate	¼ lb.
Calcium sulphate	1 oz.	Potassium iodide	2 oz.
Candles	——	Potassium nitrate	¼ lb.
Cannel coal	½ lb.	Potassium nitrite	2 oz.
Carbon bisulphide	2 oz.	Silver nitrate	1 oz.
Charcoal	½ lb.	Soap	½ lb.
Cobalt chloride	½ oz.	Sodium (metallic)	¼ oz.
Cochineal	¼ oz.	Sodium arsenite	2 oz.
Coins	——	Sodium carbonate	1 lb.
Copper (filings or turnings)	1 lb.	Sodium chloride	1 lb.
Copper nitrate	3 oz.	Sodium hydrate	1 lb.
Copper oxide	2 oz.	Sodium hyposulphite	½ lb.
Chlorhydric acid	10 lb.	Sodium nitrate	½ lb.
Ferrous sulphate	4 oz.	Sodium sulphide	¼ lb.
Ferrous sulphide	3 lb.	Sodium sulphite	1 oz.
Filter papers (4 in.)	1000	Sodium phosphate	3 oz.
Fluor spar (powdered)	3 oz.	Starch	½ lb.
Fuming sulphuric acid	¼ lb.	Strontium chloride	1 oz.
Gold leaf	4 in. sq.	Sugar	¼ lb.
Indigo	1 oz.	Sulphuric acid	12 lb.
Iodine	½ oz.	Tin chloride	2 oz.
Lead	½ lb.	Turkey red cloth	⅓ yd.
Lead acetate	2 oz.	Turpentine (spirits)	1 oz.
Lead nitrate	½ lb.	Water glass	1 lb.
Lead protoxide	1 oz.	Yeast	1 cake
Lime (unslaked)	1 lb.	Zinc	1 lb.
Litmus	1 oz.	Zinc chloride	2 oz.

RULES AND SUGGESTIONS FOR THE LABORATORY.

1. Each pupil must furnish a cloth or sponge to keep his table clean, and any apron or other clothing desired for use in the laboratory. These latter are indispensable for preserving the clothing.

2. The table occupied by pupils must be left clean and dry after every laboratory exercise. Wash and wipe dry a ring stand, or any other apparatus on which a reagent has fallen, wipe out a p.t. after using it, and keep reagent bottles, other apparatus, books, and lockers clean.

3. Pupils are held responsible for apparatus, and must replace anything that is broken or lost.

4. Have every d.t. and stopper fit tightly, to prevent leakage of gas. If a gas generates well but does not pass into the receptacle, there is some leakage, due probably to loose bearings.

5. In heating a t.t. on the r.s., hold the lamp in the hand, moving it slowly.

6. Mixtures of solids should be made on paper or in an e.d. Be careful not to mix chemicals or reagents except as directed.

7. To shake the contents of a t.t., cover its mouth with the thumb or the hand, hold it away from the table, and shake it vigorously.

8. Never put down a stopper when using a reagent bottle, but hold it between the first and second fingers, and replace it as soon as you are through using it. Do not pour back any excess of a reagent from a t.t. or other rec. into a reagent bottle, and do not dip a stirring-rod into a reagent bottle.

9. In pouring a liquid into a graduate or t.t., hold the latter on a level with the eye, placing the thumb-nail at the upper limit to which it is desired the liquid should reach.

10. Pour only liquids or fine powders into the bowls, always opening the jet at first, to let the water run. Solids should be thrown into the jars.

11. Have flasks and t.t. perfectly dry on the outside before applying heat. If there are no racks for t.t., they may conveniently rest in the rec. when not in use.

12. Reagents for general use must not be taken to the individual's table, but must be left at the side-table.

13. In experimenting, follow the directions as closely as possible. Read an exp. through before performing any part of it. Ask an explanation of anything you do not understand.

14. Read the "Model for Taking Notes." Begin to write your notes on the page opposite the exp. Both name and symbolize substances once in each exp.; as, manganese dioxide, MnO_2. After that use the symbols only. In writing equations, use only symbols. If a symbol or a name is not intelligible, refer to the table of "Symbols and Names."

15. In memorizing exps., learn names, symbols, processes, products, and reactions. Do not try to remember quantities.

16. Try to enter into the spirit of the work, by making close observations, and ascertaining what each exp. teaches. Always state whether heat has to be applied, whether the action is vigorous, and what is the color and what the state of the product.

17. No notes are to be written in this book outside of the laboratory, without special permission. Books must be brought to the teacher for inspection after each exp., and must be left in the laboratory at the end of the hour. No other books are to be used in the laboratory.

18. With the book closed, write your name and the division to which you belong distinctly across the front edge, in Roman letters.

19. For burns, put some dried Na_2CO_3 or $HNaCO_3$ on a handkerchief, moisten it, and bind it on the part affected. If taken in season no blister need occur, and the pain is soon allayed.

MODEL FOR TAKING NOTES.

49. To Make Nitrogen Protoxide.

I led a d.t. from a flask to a large t.t. immersed in water, and from this another d.t. to a p.t.

I put into the flask 10g ammonium nitrate, NH_4NO_3, and heated.

At first the NH_4NO_3 melted, then a gas appeared to come off. A liquid collected in the bottle. This I found to be neutral to litmus, but it tasted like NH_4NO_3. I concluded it was water and NH_4NO_3. A colorless gas collected in the rec. over water. It was nitrogen protoxide, N_2O.

NH_4NO_3 had been separated into H_2O and N_2O.

$NH_4NO_3 = 2\,H_2O + N_2O$.

ABBREVIATIONS.

ap. — Apparatus.
cc. — Cubic centimeter.
ch. — Chemicals.
cm. — Centimeter.
def. sp. — Deflagrating spoon.
dil. — Dilute.
down. disp. — Downward displacement.
d.t. — Delivery tube.
e.d. — Evaporating dish.
exp. — Experiment.
g. — Gram.
gen. — Generator.
i.t. — Ignition tube.
lit. — Litmus paper.
ppd. — Precipitated.
ppn. — Precipitation.
ppt. — Precipitate.
p.t. — Pneumatic trough.
rec. — Receiver.
r.s. — Ring stand.
sat. — Saturated.
sol. — Solution (aqueous).
st.r. — Stirring rod.
t.t. — Test tube.
up. disp. — Upward displacement.

TABLE OF ELEMENTS.

	NAME.	SYM.	VAL.	AT. WT.	V.D.	STATE.
Negative or Non-metallic Elements. Acid-forming with H (usually OH).	Oxygen	O	II	16	16	G
	Sulphur	S	II, IV, (VI)	32	32	S
	Nitrogen	N	(I), III, V	14	14	G
	Fluorine	F	I, (V)	19		G
	Chlorine	Cl	I, (V)	35.5	35.5	G
	Bromine	Br	I, (V)	80	80	L
	Iodine	I	I, (V)	127	127	S
	Phosphorus	P	(I), III, V	31	62	S
	Arsenic	As	III, V	75	150	S
	Carbon	C	(II), IV	12		S
	Antimony	Sb	III, V	122		S
	Silicon	Si	IV	28		S
	Hydrogen	H	I	1	1	G
Positive or Metallic Elements. Base-forming with OH.	Gold	Au	(I), III	196		S
	Platinum	Pt	(II), IV	197		S
	Mercury	Hg	I, II	200	100	L
	Silver	Ag	I	108		S
	Copper	Cu	I, II	63		S
	Tin	Sn	II, IV	118		S
	Lead	Pb	II, IV	206		S
	Iron	Fe	II, IV, (VI)	56		S
	Zinc	Zn	II	65	32½	S
	Manganese	Mn	II, IV, VI	55		S
	Aluminium	Al	(II), IV	27		S
	Magnesium	Mg	II	24		S
	Calcium	Ca	II	40		S
	Barium	Ba	II	137		S
	Sodium	Na	I	23		S
	Potassium	K	I	39		S

SYMBOLS AND NAMES.

Symbols.	*Chemical Names.*	*Common Names.*
Ag_2Br	Argentous bromide.	
$AgBr$	Argentic bromide	Bromide of silver.
Ag_2Cl	Argentous chloride.	
$AgCl$	Argentic chloride	Chloride of silver.
$AgNO_3$	Argentic nitrate	Nitrate of silver.
Ag_2S	Argentic sulphide.	
$Al_2(NO_3)_6$	Aluminic nitrate.	
$Al_2(OH)_6$	Aluminic hydrate.	
$AsCl_3$	Arsenious chloride.	
As_2O_3	Arsenious oxide	White arsenic.
As_2S_3	Arsenious sulphide.	
$AuCl_3$	Auric chloride	Chloride of gold.
$Ba(C_2H_3O_2)_2$	Barium acetate.	
$BaCl_2$	Barium chloride.	
$BaCrO_4$	Barium chromate.	
$BaCO_3$	Barium carbonate.	
$Ba(NO_3)_2$	Barium nitrate.	
$BaSO_4$	Barium sulphate.	
$Bi(NO_3)_3$	Bismuthous nitrate.	
$Bi(OH)_3$	Bismuthous hydrate.	
Bi_2S_3	Bismuthous sulphide.	
$C_{10}H_{16}$	Turpentine (hydrocarbon)	Spirits of turpentine.
$C_6H_{10}O_5$	Starch (carbohydrate).	
$C_{12}H_{22}O_{11}$	Sucrose (carbohydrate)	Sugar.
$C_{18}H_{30}O_{15}$	Cellulose (carbohydrate)	Woody fibre.
C_2H_5OH	Ethyl hydrate	Alcohol.
CO	Carbon protoxide	Carbonic oxide.
CO_2	Carbon dioxide	Carbonic acid gas.
CS_2	Carbon disulphide	Bisulphide of carbon.
$Ca(C_2H_3O_2)_2$	Calcium acetate.	
CaC_2O_4	Calcium oxalate.	
$CaCO_3$	Calcium carbonate	Carbonate of lime.
$CaCl_2$	Calcium chloride.	
$Ca(ClO)_2$	Calcium hypochlorite	In bleaching powder.
CaF_2	Calcium fluoride	Fluor spar.
CaO	Calcium oxide	Unslaked lime.
$Ca(OH)_2$	Calcium hydrate	Slaked lime.
$CaSO_4$	Calcium sulphate	Sulphate of lime.

Symbols.	*Chemical Names.*	*Common Names.*
$Cd(NO_3)_2$	Cadmium nitrate.	
CdS	Cadmium sulphide.	
$Co(C_2H_3O_2)_2$	Cobaltous acetate.	
$CoCl_2$	Cobaltous chloride.	
$Co(OH)_2$	Cobaltous hydrate.	
CoS	Cobaltous sulphide.	
Cr_2Cl_6	Chromic chloride.	
$Cr_2(NO_3)_6$	Chromic nitrate.	
$Cr_2(OH)_6$	Chromic hydrate.	
$CuCl_2$	Cupric chloride.	
$Cu(NO_3)_2$	Cupric nitrate.	
CuO	Cupric oxide	Black copper oxide.
CuS	Cupric sulphide.	
$CuSO_4$	Cupric sulphate	Blue vitriol.
$Cu_2Fe(CN)_6$	Cupric ferrocyanide.	
$FeCl_2$	Ferrous chloride.	
$Fe_2(NO_3)_6$	Ferric nitrate.	
Fe_3O_4	Ferric tetroxide	Magnetic oxide.
$Fe(OH)_2$	Ferrous hydrate.	
$Fe_2(OH)_6$	Ferric hydrate.	
FeS	Ferrous sulphide	Sulphide of iron.
$FeSO_4$	Ferrous sulphate	Copperas.
$(FeSO_4)_2NO$	Nitrosyl ferrous sulph.	
$Fe_2(SO_4)_3$	Ferric sulphate.	
$HC_2H_3O_2$	Acetic acid	Found in vinegar.
$H_2C_4H_4O_6$	Tartaric acid.	
H_2CO_3	Carbonic acid.	
HCl	Chlorhydric acid	Muriatic acid.
$HClO$	Hypochlorous acid.	
HF	Fluorhydric acid.	
$HKSO_4$	Hydrogen pot. sulphate	Acid pot. sulphate.
HNO_3	Nitric acid	Aqua fortis.
$HNaCO_3$	Hydrogen sod. carbonate	Bicarbonate of soda.
HNa_2PO_4	Hyd. disodium phosphate	Sodic phosphate.
$HNaSO_4$	Hyd. sodium sulphate	Acid sod. sulphate.
H_2O	Hyd. oxide	Water.
H_2S	Hyd. sulphide	Sulphurettedhydrogen.
H_2SO_3	Sulphurous acid.	
H_2SO_4	Sulphuric acid	Oil of vitriol.
$H_2S_2O_7$	Fuming sulph. acid	Nordhausen acid.
H_4SiO_4	Silicic acid.	
$HgCl$	Mercurous chloride	Calomel.
$HgCl_2$	Mercuric chloride	Corrosive sublimate.
$HgNO_3$	Mercurous nitrate.	
$Hg(NO_3)_2$	Mercuric nitrate.	
HgS	Mercuric sulphide.	
$K_2Al_2(SO_4)_4$	Potassium alumin. sulphate	Alum.
KBr	Potassium bromide	Bromide of potash.
KCl	Potassium chloride.	

Symbols.	*Chemical Names.*	*Common Names.*
$KClO_3$	Potassium chlorate	Chlorate of potash.
KCN	Potassium cyanide.	
$K_6Co_2(NO_2)_{12}$	Potassium cobaltic nitrite.	
K_2CrO_4	Potassium chromate.	
$K_2Cr_2O_7$	Potassium dichromate	Bichromate of potash.
$K_4Fe(CN)_6$	Potassium ferrocyanide	Yellow prussiate of pot.
KI	Potassium iodide.	
KNO_2	Potassium nitrite.	
KNO_3	Potassium nitrate	Saltpetre, nitre.
K_2O	Potassium oxide.	
KOH	Potassium hydrate	Caustic potash.
K_2SO_4	Potassium sulphate.	
K_4SiO_4	Potassium silicate	Water glass.
$MgCl_2$	Magnesium chloride.	
$Mg(NH_4)_2(CO_3)_2$	Magnesium ammonium carb.	
$Mg_3(PO_4)_2$	Magnesium phosphate.	
$MgSO_4$	Magnesium sulphate	Epsom salt.
MgO	Magnesium oxide.	
$MnCl_2$	Manganous chloride.	
$Mn(OH)_2$	Manganous hydrate.	
MnO_2	Manganic oxide	Black manganese oxide.
MnS	Manganous sulphide.	
$MnSO_4$	Manganous sulphate.	
$(NH_3)_3(AgCl)_2$	Ammonio-argentic chloride.	
$(NH_4)_3AsO_3$	Ammonium arsenite.	
$(NH_4)_3AsS_3$	Ammonium sulpharsenite.	
$NH_4C_2H_3O_2$	Ammonium acetate.	
$(NH_4)_2CO_3$	Ammonium carbonate.	
$(NH_4)_2C_2O_4$	Ammonium oxalate.	
NH_4Cl	Ammonium chloride	Sal ammoniac.
NH_2Hg_2Cl	Amido-mercurous chloride.	
NH_4MgAsO_4	Ammon. magnes. arseniate.	
NH_4MgPO_4	Ammon. magnes. phosphate.	
NH_4NO_3	Ammon. nitrate.	
NH_4OH	Ammon. hydrate	Aqua ammonia.
$(NH_4)_2S$	Ammon. sulphide.	
$(NH_4)_2SO_4$	Ammon. sulphate.	
N_2O	Nitrogen protoxide	Nitrous oxide.
NO or N_2O_2	Nitrogen dioxide	Nitric oxide.
NO_2 or N_2O_4	Nitrogen tetroxide	Nitrogen peroxide.
$NOCl$	Nitrosyl chloride	Nitrogen oxychloride.
$Na_2Al_2O_4$	Sodium aluminate.	
Na_3AsO_3	Sodium arsenite.	
Na_2CO_3	Sodium carbonate	Carbonate of soda.
$NaCl$	Sodium chloride	Common salt.
Na_2CrO_4	Sodium chromate.	
$NaNO_3$	Sodium nitrate	Chili saltpetre.
Na_2O	Sodium oxide.	
$NaOH$	Sodium hydrate	Caustic soda.

Symbols.	*Chemical Names.*	*Common Names.*
Na_2S	Sodium sulphide.	
Na_2SO_3	Sodium sulphite.	
Na_2SO_4	Sodium sulphate	Glauber's salt.
$Na_2S_2O_3$	Sodium thiosulphate	Hyposulphite of sod.
Na_4SiO_4	Sodium silicate	Water glass.
Na_2ZuO_2	Sodium zincate.	
$Ni(C_2H_3O_2)_2$	Nickelous acetate.	
$NiCl_2$	Nickelous chloride.	
$Ni(OH)_2$	Nickelous hydrate.	
NiS	Nickelous sulphide.	
P_2O_3	Phosphorus trioxide.	
P_2O_5	Phosphorus pentoxide.	
$PbBr_2$	Lead bromide.	
$Pb(C_2H_3O_2)_2$	Lead acetate	Sugar of lead.
$PbCO_3$	Lead carbonate	White lead.
$Pb(CN)_2$	Lead cyanide.	
$PbCl_2$	Lead chloride.	
$PbCrO_4$	Lead chromate	Chrome yellow.
$Pb_2Fe(CN)_6$	Lead ferrocyanide.	
PbI_2	Lead iodide.	
$Pb(NO_3)_2$	Lead nitrate.	
PbO	Lead oxide	Litharge.
$Pb(OH)_2$	Lead hydrate.	
PbS	Lead sulphide.	
$PbSO_3$	Lead sulphite.	
$PbSO_4$	Lead sulphate.	
SO_2	Sulphur dioxide	Sulphurous acid.
$SbCl_3$	Antimonious chloride.	
Sb_2O_3	Antimonious oxide.	
$SbOCl$	Antimonyl chloride.	
$(SbO)_2C_4H_4O_6$	Antimonyl tartrate.	
Sb_2S_3	Antimonious sulphide.	
SiF_4	Silicic fluoride.	
SiO_2	Silicic oxide	Silica, quartz, sand.
$SnCl_2$	Stannous chloride.	
$SnCl_4$	Stannic chloride.	
$Sn_3(PO_4)_2$	Stannous phosphate.	
SnS	Stannous sulphide.	
SnS_2	Stannic sulphide.	
$Sn_2(SO_4)_3$	Stannic sulphate.	
$Sr(C_2H_3O_2)_2$	Strontium acetate.	
$SrCO_3$	Strontium carbonate.	
$SrCl_2$	Strontium chloride.	
$SrSO_4$	Strontium sulphate.	
$Zn(C_2H_3O_2)_2$	Zincic acetate.	
$ZnCl_2$	Zincic chloride.	
$Zn(NO_3)_2$	Zincic nitrate.	
ZnS	Zincic sulphide.	
$ZnSO_4$	Zincic sulphate	White vitriol.

SOLUTIONS FOR REAGENTS AND ANALYSIS.

Number of Grams of Solids to 500cc of H_2O.

These solutions should be prepared (with distilled water preferably) filtered if necessary, and placed on shelves or a side-table for class use

$AgNO_3$ 25	$Hg(NO_3)_2$.....10	$NaNO_3$ 20
$BaCl_2$ 50	$K_2Al_2(SO_4)_4$.....50	NaOH.....60
$Ba(NO_3)_2$.....30	KBr.....25	Na_2S 20
$Bi(NO_3)_3$.....10	KCN.....50	Na_2SO_3 100
$C_{12}H_{22}O_{11}$ .....sat.	K_2CrO_4 50	$Na_2S_2O_3$ .....sat.
$CaCl_2$ 60	$K_2Cr_2O_7$.....50	NH_4Cl.....60
$Ca(OH)_2$ .....sat.	$K_4Fe(CN)_6$ 40	$(NH_4)_2C_2O_4$ 20
$CaSO_4$.....sat.	KI.....25	NH_4NO_3.....50
$Cd(NO_3)_2$.....10	KNO_2 50	$(NH_4)_2SO_4$..... 5
$CoCl_2$ 10	KNO_3 50	$NiCl_2$.....10
$CuCl_2$ 50	KOH.....60	$Pb(C_2H_3O_2)_2$ 50
$Cu(NO_3)_2$.....50	$MgCl_2$.....50	$Pb(NO_3)_2$.....100
$FeSO_4$*.....50	$MgSO_4$ 50	$SnCl_2$†.....40
$HNaCO_3$.....50	$MnCl_2$.....50	$SrCl_2$.....50
HNa_2PO_4 42	Na_3AsO_3†.....60	$SbCl_3$†..... 5
$HgCl_2$.....30	NaCl.....50	$ZnCl_2$.....10
$HgNO_3$ 25 + 25ccNHO_3	Na_2CO_3.....50	

$(NH_4)_2CO_3$ 100g, H_2O 400cc, NH_4OH 100cc.

$(NH_4)_2S$. Pass H_2S through NH_4OH (diluted as below) till the sol. gives no ppt. with $MgSO_4$ sol.

Cochineal sol. is prepared by pulverizing 6g cochineal insects and covering for several days with a mixture of 400cc H_2O and 100cc alcohol, then filtering.

Litmus sol. is prepared by heating for several hours over a water-

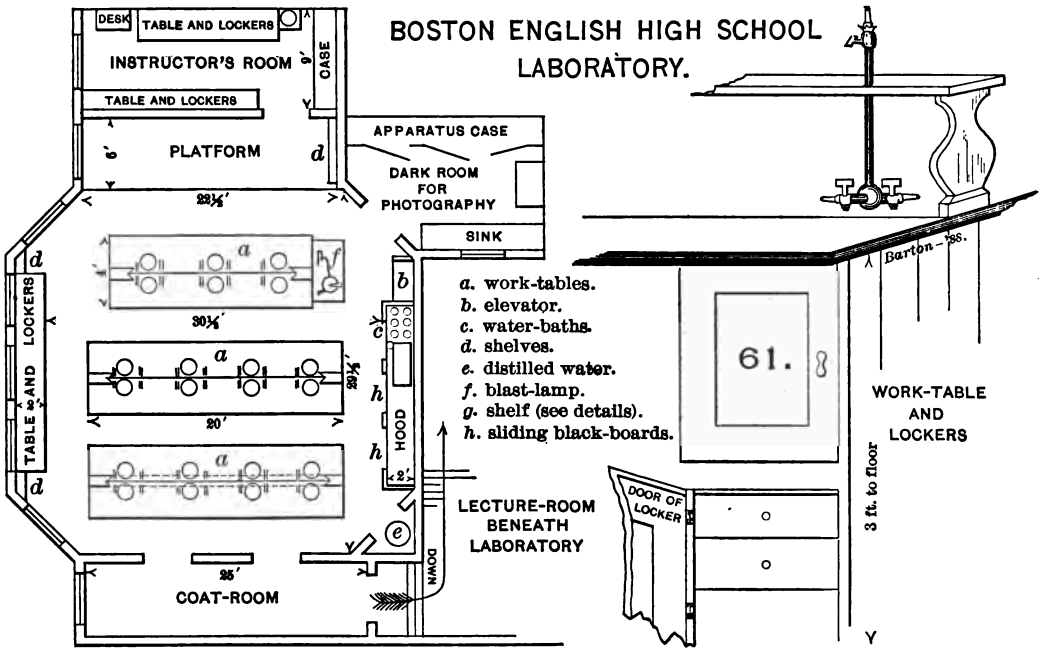
* Prepare only as wanted. † Acidulate with HCl.

bath, 80g of pulverized litmus in 500cc of water, replacing the water as it evaporates, then filtering. Keep the sol. in an *open* bottle.

Indigo sol. (sulphindigotic acid) is made by slowly mixing and stirring 5g indigo with 25cc $H_2S_2O_7$ (fuming sulphuric acid) in a beaker immersed in cold water. Cover the beaker, and after 48 hours add 500cc H_2O; stir and filter.

Dilute acids are made by mixing one volume of the acid with four volumes of water NH_4OH should be diluted with three times its volume of water before using.

INDEX TO EXPERIMENTS.


BOSTON ENGLISH HIGH SCHOOL
LABORATORY.
DESK
TABLE AND LOCKERS
INSTRUCTOR'S ROOM
CASE
TABLE AND LOCKERS
PLATFORM
22½'
APPARATUS CASE
DARK ROOM FOR PHOTOGRAPHY
SINK
a. work-tables.
b. elevator.
c. water-baths.
d. shelves.
e. distilled water.
f. blast-lamp.
g. shelf (see details).
h. sliding black-boards.
30½'
20'
HOOD
2'
LECTURE-ROOM BENEATH LABORATORY
DOWN
25'
COAT-ROOM
TABLE AND LOCKERS
61.
Barton - '88.
WORK-TABLE AND LOCKERS
3 ft. to floor
DOOR OF LOCKER

1. LENGTH.

[*Read* RULES AND SUGGESTIONS.]

Ap.: metric ruler, 30^{cm} long, test-tube.

1. Note the length of 10^{cm} on a metric ruler.
2. Estimate by the eye alone this distance on the cover of a book.
3. Verify the result.
4. Estimate the same on a t.t., and verify.
5. Try with different objects till you carry in mind 10^{cm}.
6. Estimate the number of inches it covers, and verify.
7. In the same way experiment with 1^{cm}.
8. Measure the perpendicular distance between the blue lines of foolscap.
9. Measure the diameter of the *old* nickel five-cent piece.
10. Measure and estimate in the same way 5^{cm}.
11. Make a drawing of these measurements on the opposite page: one square decimeter, *i.e.* 10^{cm} on a side; 1^{qcm}.

2. VOLUME.

Ap.: graduate holding 25 or 50^{cc}.

1. Into a graduate put 10^{cc} of water, then pour it into a t.t.
2. Note, without marking, what proportion of the t.t. is filled. Make a drawing of it on the opposite page.
3. Pour out the water, then put into the t.t. the same quantity, estimating it by the eye alone.
4. Verify the result by pouring the water into the graduate.
5. Repeat this till you can estimate quite accurately.
6. Try it with a t.t. of another size.
7. Estimate 1^{cc} of a liquid in a similar way.
8. Estimate also 5^{cc}.
9. Draw figures of a graduating glass, and of a cube 1^{cm} on a side.
10. In subsequent experiments estimate volumes, without measuring, unless special accuracy is required.

3. WEIGHT.

Ap.: pair of scales, 1, 5, 10^g weights.
Ch.: 50^g fine salt.

1. Balance a piece of paper on each pan of a pair of scales.
2. On one pan put a 10^g weight, and balance this with fine salt.
3. Note with the eye the quantity of salt, then remove it.
4. Now estimate the same quantity, and verify by weighing it.
5. Repeat the experiment several times.
6. Weigh 1^g and estimate as before.
7. See if 1^g can be piled on a one-cent coin.
8. Experiment with 5^g in a like way.
9. Make drawings of 1, 5, and 10^g weights.
10. In subsequent experiments estimate quantities of solids, unless accuracy is desired.

4. THE MOLECULAR STATE.

Ap.: Bunsen burner (or alcohol lamp), two test-tubes, funnel, filter paper.

Ch.: 2^g sugar. [*Read* RULE 17.]

1. Put into a t.t. 2^g sugar, $C_{12}(H_2O)_{11}$, and cover it with 5^{cc} H_2O.
2. Boil it in a Bunsen flame for a minute, using the wooden test-tube holder, till the sugar disappears.
3. When cool, taste a drop of the liquid.
4. Arrange a filter paper and filter the liquid, catching the filtrate in another t.t.
5. Touch a drop of the filtrate to the tongue. Has the sugar gone through the filter paper?
6. Pour out half of the liquid, and save the rest for Exp. 5.
7. Take full notes of this experiment and all subsequent ones, describing what you do, what you see, and what you infer. Read the "Model for Taking Notes."

a small quantity of sugar ... a test tube and ... with ... the sugar was dissolved.

5. ELEMENTS AND THE ATOMIC STATE.

Ap.: test-tube.
Ch.: sugar solution, 3cc sulphuric acid.

1. To the remainder of the sol., Exp. 4, slowly add an equal volume of H_2SO_4.
2. If the color is unchanged, add more.
3. Notice whether the temperature of the t.t. increases.
4. Observe any change of color, volume, and state, in the product.
5. Clean the t.t. with water.
6. Explain the phenomena, stating the action of H_2SO_4 on sugar. Is it a physical or a chemical change, and why?

Half of the solution

6. CHEMICAL UNION.

Ap.: piece of ignition tubing (15^{cm} long, 1^{cm} diam.), lamp. Ch. : 2^{g} brimstone, 1^{g} Cu turnings.

1. Mix well on paper 2^{g} S (brimstone, coarsely powdered) and the same *bulk* of Cu turnings, and put into a small i.t., made by drawing out a glass tube in the flame.
2. Hold the mixture in the flame till the substance becomes red hot throughout.
3. Break the tube with a jet of water and examine the contents. See whether they resemble either S or Cu. Describe the appearance.
4. Among the other notes write the equation for the chemical change, *and explain it.* Omit atomic and molecular weights in the laboratory.

1. I mixed thoroughly [illegible] sulphur and Cu turnings.

2. The mixture was held in the [illegible] until the bright glow was noticed. this showed the chemical union of the S and Cu.

3. The tube was broken with a hammer and the contents examined. They did not resemble either Cu or S. They were bluish black.

Cu + S = CuS. Copper sulphide is formed, it is a change and a mechanical mixture is not a chemical compound

7. TO PREPARE APPARATUS.

Ap.: lamp, round file, glass tubing (50^{cm} long, $\frac{1}{4}$ in. diam.), 2 corks.

1. Bend a piece of glass tubing about 8^{cm} from the end by holding it *lengthwise* of an ordinary gas flame, which should not be more than 5^{cm} across. In doing this hold each end of the glass between the first and second fingers and the thumb; rotate it slowly from you with the thumb and forefinger of the right hand, holding it steadily in the flame until it yields; then, without twisting, bend the ends at right angles towards you. Make another bend 6 or 8^{cm} from the first, holding the tubing by the ends, keeping it constantly in the flame, and slowly rotating it without twisting; while making this bend turn the glass so as to look lengthwise of it, and have the three parts lie in the same plane. *Avoid having the heated glass come in contact with any cool surface.*
2. Make other bends. Show your results to the instructor and, if approved, prepare one or more d.t., 40 or 50^{cm} long, as in the models, which must first be carefully examined as to the length of each part and the angles. Make the bends in the order directed.
3. With a round file bore a small hole in a cork, taking care to have it perpendicular to the faces of the cork. It must be *perfectly circular, and a little smaller than the d.t.* which it is to receive.

8. TO MAKE OXYGEN.

[*Read* RULES 2, 4, 5, 6.]

Ap.: r.s., lamp, p.t., t.t., d.t., 4 rec.
Ch.: 5^g $KClO_3$, 4^g MnO_2.

1. Mix 5^g $KClO_3$ with 3 or 4^g of fine MnO_2. Do not pulverize the $KClO_3$.
2. Put the mixture into a large t.t., which should not be over half-full.
3. Adjust a stopper and d.t., and hang the apparatus on a r.s., having the end of the d.t. in a p.t.
4. Fill four wide-mouthed bottles with H_2O, and invert them on the shelf of the p.t., with water 1 or 2^{cm} above the shelf.
5. Put a flame against the t.t., holding the lamp and slowly moving it. Avoid heating too long in one place.
6. Catch the escaping gas in the inverted rec.
7. Take out the end of the d.t. from the p.t., as soon as the lamp is removed, to prevent the water from drawing back.
8. Remove the rec. when full, keeping them covered with glass plates.
9. After making exps. 9, 10, 11, 12, clean the t.t. by covering the residue with water, closing the mouth of the t.t. with the thumb, and shaking the contents vigorously, away from the table.
10. Notes and equation. $KClO_3 = ?$

9. TO BURN CARBON IN OXYGEN.

Ch.: rec. of O, splinter.

1. Put a burning stick into a rec. of O, and notice the combustion.
2. Remove, blow out the flame, and put in the stick again while red hot. Describe the result. Repeat this till there is no longer any effect.
3. Wood consists mostly of C and of H. $C + 2\,O = ?$ $2\,H + O = ?$ Omit the *explanation* of equations except where called for.

10. TO BURN SULPHUR IN OXYGEN.

Ap.: Cu wire, piece of crayon (3^{cm} long), lamp.
Ch.: rec. of O, piece of S (size of a pea).

1. Hollow out the end of a crayon or an electric-light pencil, and attach a Cu wire for a deflagrating spoon.
2. Put into it a bit of S, hold in the flame till the S burns, then lower it into a rec. of O. Notice the color and vigor of the flame.
3. When combustion ceases, remove the wire and cautiously take the odor.
4. $S + 2\,O = ?$ Mention the color, state, odor, and name of the product.

11. TO BURN PHOSPHORUS IN OXYGEN.

Ap.: forceps, def. sp. (wire and crayon), wire, lamp.
Ch. : piece of P (size of half a pea), rec. of O.

1. With the forceps put into a def. sp. a bit of P, half as large as a pea, after first drying it with paper.
2. Heat one end of a wire or some metal, touch the P with it, and lower the P at once into a rec. of O.
3. When combustion ceases, remove and burn every bit of the P by holding it in a flame.
4. Describe the flame and the product. $2P+5O=?$ $2P+3O=?$

12. TO BURN IRON IN OXYGEN.

Ap.: lamp, e.d.
Ch.: rec. of O, little S, picture-cord wire (10^{cm} long).

1. With forceps hold one end of a picture-cord wire, or a steel shaving, 5 or 10^{cm} long, in a flame for an instant, then dip it into a bit of powdered S.
2. Hold it again in the flame till the S burns, then put it into a rec. of O, with a little H_2O in the bottom.
3. If the Fe does not burn, repeat with another rec. Have but little S on the wire. $3\,Fe + 4\,O = ?$

13. TO SEPARATE NITROGEN.

Ap.: e.d., p.t., def. sp., rec. and glass, forceps, wire, lamp.
Ch.: piece of P (half the size of a pea).

1. Fill a p.t. with water to 1 or 2^{cm} above the shelf.
2. Prepare a def. sp. with the wire bent sharply 5 or 6^{cm} from the bowl of the spoon.
3. Pass the wire through the orifice in the shelf of the p.t., fasten it there, and invert a rec. or small graduate over it, so as to seal the mouth under water. When easily adjustable, remove the rec., leaving the wire.
4. Using forceps and e.d., dry a piece of P (size of half a pea) on paper, and put it into the spoon.
5. Touch it with a hot wire or the handle of a file, and instantly invert the rec. over it as before. Hold the rec. steadily with the hand till combustion ceases.
6. Before removing the def. sp. be sure that combustion has stopped, and let no air enter. $2P+5O=?$ $2P+3O=?$
7. Finally remove the spoon, without admitting air or disturbing the rec.
8. Burn the P and leave the rec. till the gas becomes tolerably clear; then remove the rec. with a glass plate, leaving the water in the bottom. Save this for Exp. 14.
9. What is left? What becomes of the other products?

14. PROPERTIES OF NITROGEN AND COMPOSITION OF AIR.

Ap.: graduate.
Ch.: rec. of N, splinter, match.

1. Put a burning stick into the N, sliding along the glass plate enough to admit it. Note the effect. Try this with a glowing stick.
2. See whether the P and S on the end of a match will burn in the gas. Is it a supporter of combustion?
3. Why is there no equation for this experiment?
4. To find approximately the proportion of O, measure the water accurately by pouring it into a graduate. Then measure the total capacity of the rec. in the same way, and *compute the percentage of O* (by volume) in the air, remembering that the volume of water represents the volume of O burned. If any air has been forced out, the percentage of O will be too large.
5. State the percentage of O and of N in air, as shown by this experiment.

15. TO MAKE HYDROGEN.

Ap.: p.t., 4 rec., t.t., d.t., r.s.
Ch.: 5^g Zn., 15^{cc} HCl.

1. Prepare apparatus as for making O.
2. Into a t.t. put 5^g granulated Zn, 5^{cc} H_2O and 5^{cc} HCl.
3. Have the bearings perfectly tight, and collect the gas like O. No heat need be applied.
4. If the action ceases, add more HCl. Reaction.
5. Invariably keep the rec. of H inverted on a glass plate on removing them.
6. After doing the next two experiments, wash the Zn and return it.

16. COMBUSTION OF HYDROGEN.

Ap.: lamp, glass tube (10^{cm} long, $\frac{1}{2}^{cm}$ diam.), glass tube (50^{cm} long, 2 or 3^{cm} diam.), t.t., H gen., rec.
Ch.: rec. H, stick.

1. Lift an inverted rec. of H, and hold it in the same position over a flame, watching the result. Reaction.
2. Insert a burning stick into an inverted rec. of H. Note the effect on the stick and on the H.
3. Make a philosopher's lamp with a H gen., drawing out a glass tube for this purpose. Before lighting it, test the purity of the H, by exploding a test-tube full in the flame. When no sharp report ensues, light the flame; avoid pointing the tube towards any one. Reaction.
4. When it burns, lower a large glass tube (2 or 3^{cm} in diam.) over the flame.
5. Hold a *dry* bottle over the flame for some time and look for moisture on the sides.
6. Collect by up. disp. a dry t.t. of H, explode it over a flame, and look for any product.

17. EXPLOSION OF HYDROGEN.

Ap.: soda-bottle, p.t., t.t., d.t., r.s., lamp.
Ch.: 2^{g} Zn, 5^{cc} HCl.

1. Fill a soda-bottle with water, invert it in a p.t., and fill it not over one-fifth full of H.
2. Lift the bottle, inverted, to let the water run out and air take its place.
3. Cover the mouth of the bottle with the hand, and shake well, so as to mix the H and the air.
4. Now bring its mouth to a flame.

18. TO MAKE CHARCOAL.

Ap.: lamp, r.s., small Hessian crucible, sand, e.d.
Ch.: pieces of wood about 2^{cm} long or square.

1. Put 2 or 3 small and thin pieces of wood into a small Hessian crucible, and cover them with sand.
2. Apply a strong heat for half an hour, or until gases cease to come off, then let it cool; pour off the sand (save it), and examine the wood. Notice any gases rising during the experiment. Explain.
3. Hold a piece of the charcoal in a Bunsen flame. See whether it burns with flame or only glows.
4. Hold an e.d. in the flame of a Bunsen burner, having the basal orifices closed. As gas consists mainly of compounds of H and C, explain the effect.
5. Open the orifices, and try to burn off some of the deposited C.

19. DISINFECTING ACTION OF CHARCOAL.

Ap.: t.t., 2 rec., funnel, filter paper.
Ch.: 2^g FeS, 5^{cc} HCl, 5^g charcoal.

1. Prepare a sol. of H_2S (Exp. 72) in a rec. with 20^{cc} H_2O. Notice the odor.
2. Put into the rec. 5^g powdered charcoal, and shake the mixture well.
3. Pour the whole on a filter, collect the filtrate in a clean rec., and see whether any odor remains. If so, use more coal and filter again.

21. CONDENSING ACTION OF CHARCOAL.

Ap.: paper.
Ch.: 3ᵍ bone-black, P (half the size of a pea).

1. Dry a piece of P, and put it on paper 3 or 4 folds in thickness.
2. Cover it with 3ᵍ of powdered bone-black, and leave it in a warm place till combustion ensues. Explain and give equation.
3. Finally burn all the P.

22. REDUCING ACTION OF CARBON.

Ap.: lamp, i.t., e.d.
Ch.: 5^g CuO, $\frac{1}{2}^g$ charcoal (powdered), 3^{cc} HNO_3.

1. Mix on paper and put into a prepared i.t. (10^{cm} long, $\frac{1}{2}^{cm}$ diam.), 10 pts. CuO to 1 pt. C, powdered charcoal, by weight 5^g in all. The tube should not be over $\frac{1}{3}$ full.
2. Heat to redness for 5 or 10 minutes.
3. Remove the contents to a paper and look for metallic Cu. $2\,CuO+C=?$ $CuO+C=?$
4. Test it by putting some into an e.d. and adding 2 or 3^{cc} HNO_3. Observe the color of the fumes and of the liquid. $3\,Cu+8\,HNO_3=3\,Cu(NO_3)_2+4\,H_2O+2\,NO$.

23. SOLUTION AND DEPOSITION OF SILVER.

Ap.: e.d., lamp, r.s., plate.
Ch.: a dime, a cent or a Cu wire, 5cc HNO_3.

1. Put a ten-cent Ag coin or other piece of Ag into an e.d. and pour over it from a t.t. a mixture of 5cc HNO_3 and 10cc H_2O.
2. *Warm* till all or nearly all the Ag dissolves; then remove the lamp and take out any Ag that is left. $3\,Ag + 4\,HNO_3 = ?$ (See Exp. 22.)
3. Then add 10cc H_2O, and at once put into it a one-cent coin or a Cu wire.
4. Leave this till quite a deposit appears, then pour off the liquid, *wash the deposit thoroughly*, and remove it from the coin. $2\,AgNO_3 + Cu = ?$
5. Examine to see what the metal is, and save it.

24. SOLUTION AND DEPOSITION OF COPPER.

Ap.: e.d., r.s., lamp, plate.
Ch.: a cent or 2ᵍ Cu, a strip of Pb, 5ᶜᶜ HNO_3.

1. Dissolve a Cu cent or some Cu turnings in a mixture of 5ᶜᶜ $HNO_3 + 10^{cc}$ H_2O. Warm till the metal has nearly dissolved; then cool, remove the remainder (as in Exp. 23), add 10ᶜᶜ H_2O, and put in a piece of Pb about the same size as the Cu used.
2. Examine the deposit, and explain fully.
   $3\,Cu + 8\,HNO_3 = ?$
   $Cu\,(NO_3)_2 + Pb = ?$

I Mixed 5 cc HNO_3 and 10 cc H_2O and poured it over Cu turnings & heated until it was dissolved. Product was a blue liquid.

$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 4H_2O + 2NO$

Then diluted the solution with 100 cc H_2O and [illegible] Pb

$Cu(NO_3)_2 + Pb = Pb(NO_3)_2 + Cu$

Deposit is [illegible] forming on the Pb

L

25. SOLUTION AND DEPOSITION OF LEAD.

Ap.: e.d., r.s., lamp, plate.
Ch.: a piece of Pb, a piece of Zn, 5cc HNO_3.

1. Do this experiment like the two previous, dissolving a piece of Pb, not larger than a cent in 5cc HNO_3 and 10cc H_2O; warm till the Pb has nearly dissolved, cool, remove any extra Pb, add 10cc water and a piece of Zn the size of the Pb used.
2. Examine the deposit and identify it. $3\,Pb + 8\,HNO_3 = ?$ $Pb(NO_3)_2 + Zn = ?$
3. State what is shown by Exps. 23, 24, 25 of the electro-positive and electro-negative relation of Ag, Cu, Pb, and Zn.

Dissolve [illegible] of Pb in 5 cc of H
and 10 cc of [illegible] using until reaction
started.

$3\,Pb + [illegible] \rightarrow 3\,Pb(NO_3)_2 + 4\,H_2O$ +2 N.

$Pb(NO_3)_2 + Zn = Zn(NO_3)_2 + Pb$

26. WHAT ACIDS ARE.

Ap.: e.d., stirring rod.
Ch.: HCl, HNO_3, H_2SO_4 (a few drops each), litmus paper (small strips).

1. Pour into an e.d. a few drops HCl, add 5^{cc} H_2O, stir it, and taste a drop from the st.r.
2. Dip the end of a strip of blue litmus paper into it; notice the effect.
3. Wash the e.d. well, then put in a few drops of HNO_3 and 5^{cc} H_2O and stir.
4. Notice the taste of this, and its action on blue litmus, as before.
5. Prepare and test similarly H_2SO_4.
6. State your conclusions as to the action and the composition of acids, and frame a definition. Observe in this connection the common element in the three acids, and whether the rest of the symbol is negative or positive.

Dilute HCl turns blue litmus red and tastes sour

Dilute HNO_3 turns blue litmus red

27. WHAT BASES ARE.

Ap.: e.d., st.r.

Ch.: NH_4OH, NaOH, KOH (a few drops each), HCl, litmus paper (strips).

1. Pour into an e.d. a few drops of NH_4OH, add 5^{cc} H_2O, stir it, and taste a drop.
2. Dip the end of a strip of *red* litmus paper into it. To redden blue litmus hold it in the *fumes* of HCl. To change red litmus to blue, hold it in the *fumes* of NH_4OH. One piece of litmus paper can thus be used repeatedly.
3. Wash the e.d. and prepare and test NaOH sol. in the same way.
4. Do the same with KOH sol.
5. State your conclusions regarding the action and the composition of bases. Observe the two common elements in the three bases, and whether the rest of the symbol is negative or positive. Give a definition.

The dilute bases turn red litmus blue
OH is in all the bases and in
the rest is [illegible]

28. ACID AND ALKALINE REACTIONS.

Ap.: beaker, st.r., e.d.

Ch.: 5^{cc} lit. sol., HCl, HNO_3, H_2SO_4, NH_4OH, KOH sol. NaOH sol. (a few drops each).

1. Pour into a small beaker or a t.t. 5^{cc} of an aqueous solution of blue litmus.
2. Pour a few drops of HCl into an e.d., and dip a st.r. into this, then stir the lit. sol. with it, noticing any change of color. If there is no change, add another drop with the rod. This shows an acid reaction.
3. Pour a few drops of NH_4OH into a clean e.d., dip the st.r. into it, then stir the lit. sol. with it. If the color is unchanged, repeat till blue is again obtained. This shows an alkaline reaction.
4. In the same way put a drop — or more if needed — of HNO_3 from an e.d. into the same blue sol. When it is reddened, add a drop or more of NaOH sol., till it becomes blue.
5. Change it again to red with a drop of H_2SO_4, and restore the color with KOH sol.

We put the litmus in an evaporating dish and added HCl until it turned red this is an acid reaction Then we added KOH until it turned blue again, this is a base reaction.

We then tried the litmus with HNO_3 and H_2SO_4 with the same result.

We then tested the litmus red with H_2SO_4 and [illegible] with KOH.

29. WHAT SALTS ARE.

Ap.: e.d.

Ch.: sol. of NaCl, KNO_3, $(NH_4)_2SO_4$, Na_2CO_3, $HNaCO_3$ (2^{cc} each), litmus.

1. Pour into a clean e.d. 1 or 2^{cc} of NaCl sol. in water, taste a drop of it, and test it with litmus.
2. Test in the same way 1 or 2^{cc} of KNO_3 sol.
3. Test similarly a sol. of $(NH_4)_2SO_4$.
4. State your conclusions as to the usual action of salts, and as to their composition.
5. Test, however, a sol. of Na_2CO_3.
6. Test, also, a sol. of $HNaCO_3$.

I made a solution of NaCl and water it tastes salt. Litmus paper shows no change in the taste.

KNO_3 solution has not much taste and does not change litmus.

$(NH_4)_2SO_4$ solution does not change litmus.

Salts usually are neutral to litmus. Salts are formed by the combination of an acid and a base

Na_2CO_3 solution turns ~~red litmus~~ red litmus blue. Evidently there is more base than acid

HNaCO solution turns red litmus blue Why?

30. TO MAKE SODIUM CHLORIDE.

Ap.: r.s., lamp, plate, asbestus, e.d., st.r., 2 t.t., beaker.
Ch.: 5^{cc} sol. NaOH, 5^{cc} HCl, litmus.

1. Measure in a t.t. 5^{cc} NaOH sol. and pour it into an e.d.
2. Pour into a clean t.t. 4 or 5^{cc} HCl, and add some of this, a little at a time, to the NaOH sol., stirring it meantime, till the product is neutral to litmus paper. When nearly neutral, add a drop at a time with the st.r. Test with both colors. Turn the paper from one color to the other as directed in Exp. 27. Use only the end of the paper, putting it on the side of the e.d. If blue litmus paper is reddened, add NaOH sol., a drop at a time. If red litmus is turned blue, add a drop of HCl.
3. When no effect is produced on either red or blue litmus after leaving for a minute, show the sol., with both red and blue litmus in it, to the instructor, then filter and evaporate the liquid to dryness by boiling it over a plate and asbestus paper.
4. When cool, examine the residue and taste it. Reaction. What is the object of evaporation?

I mixed NaOH and HCl in a separating dish in such proportions that the mixture was neutral to litmus. Then I evaporated the H_2O leaving NaCl or common table salt in the form of white crystals.

$NaOH + HCl = NaCl + H_2O$

31. TO MAKE POTASSIUM SULPHATE.

Ap.: same as in last experiment.
Ch.: 5^{cc} KOH sol., 5^{cc} H_2SO_4, litmus.

1. Into an e.d. put 5^{cc} KOH sol.
2. Neutralize it with H_2SO_4 from a t.t., as in the previous experiment.
3. When it is absolutely neutral, evaporate the water.
4. Taste the product. Give the equation.

32. TO MAKE AMMONIUM NITRATE.

Ap.: same as in previous experiment.
Ch.: 5^{cc} NH_4OH, 5^{cc} HNO_3, litmus.

1. Put into an e.d. 5^{cc} NH_4OH.
2. Neutralize this with HNO_3 from a t.t. or beaker, as in the previous experiment.
3. Evaporate till white fumes begin to appear.
4. Cool, and taste the residue. Reaction.
5. After writing up this experiment, write reactions for the union of: (1) NaOH and HNO_3, (2) NaOH and H_2SO_4, (3) KOH and HNO_3, (4) KOH and HCl, (5) NH_4OH and HCl, (6) NH_4OH and H_2SO_4. Use a separate line for each. State a method of preparing salts.

33. TO MAKE CHLORHYDRIC ACID.

Two pupils may work together.

[*Read* RULE 11.]

Ap.: r.s., lamp, plate, asbestus, flask, d.t., rec. (for Wolff bottles).

Ch.: 10^g NaCl, 20^{cc} H_2SO_4, 2^{cc} NH_4OH.

1. Into a flask put 10^g NaCl and 20^{cc} H_2SO_4. Be sure to have enough acid, or the flask will crack.
2. Fill two or more rec. one-quarter full of water.
3. Connect the apparatus as in the model, observing how the tubes extend, and having one ring above the flask to hold it.
4. Heat slowly 15 minutes over asbestus. Do not let the frothing extend to the neck of the flask. Reactions. Look for any current in the liquid of the rec. On detaching the apparatus, pass a little of the gas over some NH_4OH in an e.d. Notice the fumes, and write the equation.
5. Let the flask stand till cool, then clean it with water.

[*If the gas is accidentally breathed, inhale* NH_3.]

34. TESTS FOR CHLORHYDRIC ACID.

Ap.: t.t., e.d.

Ch.: lit., rec. HCl, bit of Zn, 2^{cc} $Pb(NO_3)_2$ sol., 2^{cc} $AgNO_3$ sol., 2^{cc} $HgNO_3$ sol.

1. Test the liquid in each rec. with lit., and taste a drop.
2. Pour 10^{cc} from the *first rec.* into a t.t., and add a piece of Zn. Reaction. Ignite the escaping gas.
3. Put into a t.t. 2^{cc} $AgNO_3$ sol., and add 2^{cc} of the liquid from the first rec. Reaction. What is the ppt.?
4. Put into a t.t. 2^{cc} $Pb(NO_3)_2$ sol., and add 2^{cc} of the liquid from the first rec. Reaction. Name the ppt.
5. Put into a t.t. 2^{cc} $HgNO_3$ sol., and add 2^{cc} of the liquid from the first rec. Name the ppt. Reaction.

The liquid [illegible] the bubbles is
$HCl + Zn = ZnCl_2 + H_2$
escaping gas lights with an explosion
$AgNO_3 + HCl = AgCl + HNO_3$
The ppt is AgCl
$Pb(NO_3)_2 + HCl$ [illegible]
ppt is $PbCl_2$
$HgNO_3 + HCl = HgCl$ [illegible]
ppt is $HgCl$

35. FLUORHYDRIC ACID AND ETCHING.

Ap.: lead tray (5 or 6^{cm} square 1^{cm} deep), r.s., lamp, plate, glass.

Ch.: 2^{g} CaF_2, 4^{cc} H_2SO_4, piece of beeswax.

1. Cover thinly with beeswax one side of a small piece of glass. Spread the wax evenly over the surface by warming the other side of the glass.
2. With a sharp metallic point mark some design through the wax when it is hard.
3. Put into a lead tray 2^{g} powdered CaF_2, cover it with H_2SO_4, and mix.
4. Lay the glass, wax side down, over the tray, and put this *high above a small flame*, so as to *warm* the contents and not melt the wax.
5. After 5 or 10 minutes remove the lamp, and leave the tray and glass in a warm place for at least half an hour; two hours would be better. Avoid inhaling the gas. $CaF_2 + H_2SO_4 = ?$
6. Remove the wax, clean the glass with a cloth wet with benzine or naphtha, and look for the design. $4\,HF + SiO_2 = ?$

36. TO MAKE NITRIC ACID.

Ap.: r.s., lamp, plate, asbestus, flask, d.t., t.t., rec.
Ch.: 5^g $NaNO_3$ (or KNO_3), 10^{cc} H_2SO_4.

1. Put into a flask or large t.t. 5^g $NaNO_3$ (or KNO_3) and 10^{cc} H_2SO_4.
2. Attach a d.t. and fit a cork tightly.
3. Put the other end of the d.t. into a t.t., and sink this to the bottom of a rec. of water.
4. Heat the flask on a r.s. over asbestus, and collect 4 or 5^{cc} of the liquid. Take care that none of the salt passes over. If a t.t. is used, put the flame against the upper part of the liquid. Avoid having the liquid draw back by removing the t.t. as soon as the heat is taken away.
5. Note the color of the acid, and account for it. Equations.

37. TESTS FOR NITRIC ACID.

Ap.: t.t., e.d.

Ch.: lit., a bit of white silk (or quill), $\frac{1}{2}^{g}$ Cu turnings, 1^{cc} cochineal sol., 1^{g} charcoal, 5^{cc} HNO_3.

1. Test with lit. the liquid prepared in the last experiment.
2. Put a drop on the finger with a st.r., and wash it off at once. Note any color.
3. Dip a quill or piece of white silk into it for an instant, then wash it, noticing the color.
4. Add a little to a few bits of Cu turnings in an e.d. Reaction. See Exp. 22.
5. To 1^{cc} indigo solution add 1^{cc} HNO_3. Result.
6. Heat in an e.d. 1^{g} fine charcoal, and then add 1^{cc} HNO_3.

2, 3, 4, 6 are characteristic tests.

38. NITRO-HYDROCHLORIC ACID.

Ap.: 2 t.t.
Ch.: 2^{qcm} Au leaf, 6^{cc} HCl, 2^{cc} HNO_3.

1. Put into each of 2 t.t. 1^{qcm} of gold leaf.
2. To one add 6^{cc} HCl, to the other 2^{cc} HNO_3. If the gold does not disappear from either, boil each for an instant.
3. Pour the two acids together, and observe.
   $3\,HCl + HNO_3 = NOCl + 2\,H_2O + ?$ $Au + 3\,Cl = ?$

39. SULPHUROUS ACID.

Ap. : lamp, 2 t.t., d.t.
Ch. : lit., 3^g Cu, 4^{cc} H_2SO_4.

1. To 2 or 3^g Cu turnings in a t.t. add 3 or 4^{cc} H_2SO_4.
2. Attach a d.t. that leads into an open t.t., in which are 5 or 10^{cc} H_2O, and attach to a r.s. Heat the t.t. containing the reagents and let the gas bubble, for 2 or 3 minutes, through the water. Cautiously take the odor.
3. Reactions for the liberation of SO_2, and for its combination with H_2O.
4. What is another mode of making H_2SO_3?

40. TO MAKE SULPHURIC ACID.

Two pupils may work together.

Ap.: 1 rec., 3 t.t., 3 d.t., 2 lamps, r.s.
Ch.: 10^g Cu turnings, 5^{cc} H_2SO_4, 5^{cc} HNO_3.

1. Fit a rec. or a large t.t. with a cork which has 4 perforations, 3 of which are to be connected by a d.t. to 3 other t.t., the fourth to be left open. Fit the stopper loosely to the rec.
2. Into one t.t. put 10^{cc} H_2O; into another 5^g Cu and 5^{cc} H_2SO_4; into the third 5^g Cu, 5^{cc} H_2O, 5^{cc} HNO_3.
3. Connect each t.t. with the rec. by a d.t. Put the rec. on an iron plate on the r.s., and heat the tubes containing H_2O and H_2SO_4, also the other if necessary. Collect a little liquid in the rec. Avoid forcing over any liquid. If any goes over from the H_2SO_4 or the HNO_3 tube, clean out the rec. and begin again.
4. Give the equation for the reaction in each t.t. and in the rec. Make a diagram of the ap.

41. TESTS FOR SULPHURIC ACID.

Ap.: t.t.

Ch.: lit., $BaCl_2$ sol. (few drops), H_2SO_4 (from previous experiment, also from reagent bottle), 2^{cc} sugar sol., splinter, starch (fragment).

1. Test with lit. the liquid generated in the previous experiment.
2. To some of the liquid poured into a t.t. add a few drops of clear $BaCl_2$ sol., and look for a ppt. This is a test for H_2SO_4, and for the soluble sulphates. Give the reaction and name the product.
3. Put one drop H_2SO_4 (from reagent bottle) into a clean t.t., add 10^{cc} H_2O, shake, add one drop $BaCl_2$ sol., and look for a ppt.
4. Put one drop of strong H_2SO_4, and one from that just made, on writing-paper, and evaporate them high over a flame, so as not to burn the paper. When dry, examine.
5. Put 2^{cc} of strong H_2SO_4 into a t.t. and dip into it a splinter. Wood and paper are mostly cellulose, $C_{18}(H_2O)_{15}$. Explain the charring.
6. To 2^{cc} sugar sol., $C_{12}(H_2O)_{11}$, add 2^{cc} H_2SO_4, and explain.
7. Cover a fragment of starch, $C_6(H_2O)_5$, with H_2SO_4 in a t.t.; boil till it begins to blacken. Explain.

42. ACTION OF SULPHURIC ACID ON WATER.

Ap.: small t.t., also large one, e.d., graduate, 2 rec.
Ch.: 2^{cc} NH_4OH, 25^{cc} H_2SO_4.

1. Into a very small t.t. put 2^{cc} NH_4OH.
2. Pour into an e.d. or a beaker 5^{cc} H_2O, and into this pour slowly 15^{cc} H_2SO_4. Use the small t.t. containing the NH_4OH for a st.r., while mixing them, and look for any ebullition. Observe, with a chemical thermometer, the temperature of the water before mixing, then of the mixture. Notice the heat of the e.d. and of the t.t.
3. Measure in a graduate exactly 10^{cc} H_2SO_4 and pour it into a rec. or beaker. Set this aside till the next lab. hour, putting into another open rec. near by, twice as much water or more. Mark the one having H_2SO_4.
4. At the next hour (next week) measure accurately the volume of H_2SO_4. Save the acid.

43. TO MAKE AMMONIUM HYDRATE.

[*Read* RULE 11.]

In this experiment two pupils may work together.

Ap.: mortar, flask, 2 (or more) rec. (for Wolff bottles), d.t., e.d., lamp, r.s., plate, and asbestus.
Ch.: 10^g NH_4Cl, 10^g $Ca(OH)_2$, 2^{cc} HCl, lit., 5^{cc} $FeSO_4$ sol.

1. Powder and put into a flask 10^g NH_4Cl and 10^g freshly slaked $Ca(OH)_2$.
2. Add 25^{cc} H_2O, and connect with Wolff bottles containing water, as in making HCl. Have the tubes as in the model.
3. Heat 10 minutes, using a plate and asbestus paper. Reaction.
4. Disconnect the flask, put 2^{cc} HCl into an e.d., and pass the gas over it from the gen. Observe the fumes, and give the reaction for them. This is the test for ammonia. Let the flask cool as it stands, and test the liquid in the rec. with red lit.
5. Put 5^{cc} $FeSO_4$ sol. into a t.t., and pour in 2 or 3^{cc} of the prepared NH_4OH. Note effect and color, and write reaction. Name the ppt.

44. AMMONIA.

Ap.: mortar, lamp, t.t.
Ch.: 5g NH_4NO_3, 5g $Ca(OH)_2$, lit.

1. Pulverize 5g NH_4NO_3 in a clean mortar.
2. Mix with it 5g fine $Ca(OH)_2$.
3. Put them into a t.t., and warm it. Equation.
4. Test the gas by holding lit. at the open end of the tube while heating it. Test it also with HCl. Equation. Notice the odor.

Mixed NH_4NO_3 in a mortar with $Ca(OH)_2$, then put them in a test tube and warmed them

$2NH_4NO_3 + Ca(OH)_2 = Ca(NO_3)_2 + 2NH_4OH$

The escaping gas NH_4OH turned red litmus blue. On bringing vapour from HCl the evolving gas forms a white [illegible]

$NH_4OH + HCl = NH_4Cl + H_2O$

$NH_3 + HCl = NH_4Cl$

45. AMMONIA.

Ap.: lamp, t.t.
Ch.: 5^g NH_4Cl (or NH_4NO_3), 5^{cc} NaOH (or KOH) sol., lit.

1. Put into a t.t. 5^g NH_4Cl (or NH_4NO_3), and add 5^{cc} NaOH (or KOH) sol.
2. Warm it and apply the same tests as before. Equation.

Mixed [illegible] NO_3 and NaOH in a test tube, heated, the escaping [illegible] wetted litmus blue, and when held in contact with escaping HCl gas formed [illegible]

$NH_4NO_3 + NaOH = NH_4OH + NaNO_3$

$NH_4OH + HCl = NH_4Cl + H_2O$

$NH_3 + HCl = NH_4Cl$

✓

46. TO MAKE POTASSIUM HYDRATE.

Ap.: rec., paper.
Ch.: K (half size of pea), lit.

1. Put 20^{cc} H_2O into a clean rec.
2. Take from the naphtha in which it is kept a piece of metallic K, using forceps and e.d.; drop it into the rec., and at once cover this loosely with paper. Note the color of the flame and the activity of the combustion.
3. When action ceases, test the liquid with red litmus, and draw an inference as to the class of compounds to which it belongs.
4. What is the color, and what the lustre of freshly cut K; also its sp. gr. as compared with water?
5. Write equations for (1) the union of K and H_2O, (2) the combustion of H, (3) the combustion of K.

47. TO MAKE SODIUM HYDRATE.

Ap.: rec., paper.
Ch.: Na (half size of pea), lit.

1. Put into a clean rec. 20^{cc} H_2O.
2. Drop into this a piece of metallic Na, and cover the rec. as in Exp. 46. Compare the color and the lustre of freshly cut Na, and its chemical activity with those of K. Equation.
3. Test the liquid with red lit., and draw inference.
4. Heat 10^{cc} H_2O in a t.t. and pour it into a rec. Drop into the hot water a piece of Na, and cover the rec. with paper. Do not watch it at too close a range. Why was it more active than before? Write three equations for this.

Put a piece of Na in a receiver of water covering the bottom with a piece of silver. $Na + H_2O = NaOH + H$

Added by

3.

48. TO MAKE SODIUM HYDRATE.

Ap.: e.d., lamp, r.s., plate, lit.
Ch.: 5^g Na_2CO_3, 2^g $Ca(OH)_2$.

1. Dissolve 5^g crystals of Na_2CO_3 in 20^{cc} H_2O, and heat just below boiling in an e.d.
2. Then add a mixture of 2^g $Ca(OH)_2$ in 8^{cc} H_2O.
3. Boil five minutes. Cool, and pour off the liquid or filter it. Test with lit. $Na_2CO_3 + Ca(OH)_2 = ?$
4. What is the insoluble residue? By evap. the NaOH can be obtained as a solid.
5. Write equation for making KOH similarly.

49. TO MAKE NITROGEN PROTOXIDE.

In this experiment two pupils may work together.

Ap.: r.s., lamp, flask, 2 d.t., 3 rec., large t.t., p.t.
Ch.: 10^g NH_4NO_3, lit.

1. Put into a flask (of 200^{cc}) 10^g NH_4NO_3.
2. Connect the flask with a large t.t. or rec., resting in a rec. of H_2O, and from this t.t. have a d.t. leading to a p.t., so as to collect the gas over water. Have the bearings tight.
3. Heat not too rapidly. Obtain 2 rec. of gas, then remove the lamp and take the d.t. from the water. Cool the flask on the r.s. • Equation.
4. Taste *a drop* of the liquid in the large t.t., and test it with red and blue lit. Some NH_4NO_3 will probably have been driven over.

50. COMBUSTION IN NITROGEN PROTOXIDE.

Ch.: rec. N_2O (2 or more), stick, S, P (small bit of each).

1. Try a burning stick in a rec. of N_2O, also a red-hot one.
2. Try the combustibility of S or of P, or both, in N_2O. Have the S burning briskly.

51. TO MAKE NITROGEN DIOXIDE.

Ap.: r.s., t.t., d.t., p.t., 2 rec.
Ch. : 5^g Cu turnings (fine), 10^{cc} HNO_3.

1. Put into a t.t. 5^g Cu turnings, 5^{cc} H_2O, 5^{cc} HNO_3.
2. Arrange the apparatus as in the H experiment, and collect the gas (2 rec.) over water.
3. If necessary, add more of reagents (Cu, H_2O, HNO_3), and moderate heat may be applied. Equation. [Exp. 22.]

[illegible] NITROGEN DIOXIDE

[illegible]

[illegible]).

1. [illegible] with the
2. [illegible] or on a

[illegible] [illegible]

[illegible]

[illegible]

[illegible]

82. COMBUSTION IN NITROGEN DIOXIDE.

Ap.: def. sp.
Ch.: splinter, S, P (same size as usual).

1. Try a burning stick in NO. Also, with the same rec., try burning S in a def. sp. or on a wire.
2. Try P when *well burning*. Admit as little air as possible. If it burns, give the equation.
3. Finally burn all the P as usual.

53. NITROGEN TETROXIDE.

Ap.: t.t., lamp.
Ch.: rec. NO, 1^g $Pb(NO_3)_2$, 1^g starch, 1^{cc} HNO_3, splinter.

1. Lift a rec. of NO from the p.t. Reaction.
2. Heat 1^g of powdered $Pb(NO_3)_2$ in a t.t. $Pb(NO_3)_2 = PbO + 2\,NO_2 + ?$
3. To 1^g of starch in a t.t. add 1^{cc} HNO_3, and heat a moment.
4. Put a burning stick into the gas. Is the latter a supporter of combustion?

54. CARBON DIOXIDE.

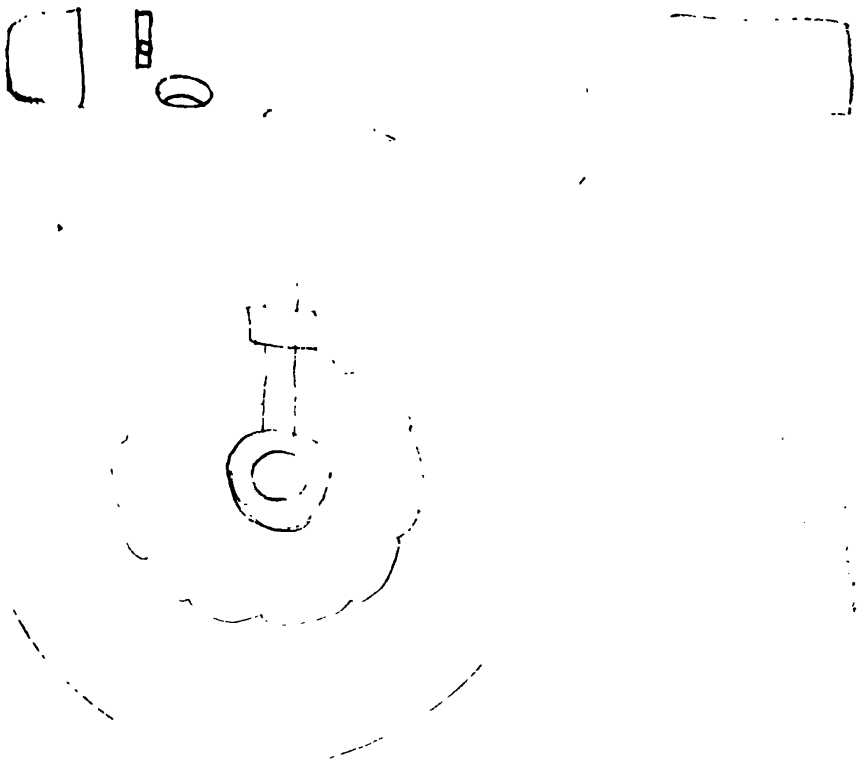
Ap.: 2 t.t., d.t., rec., lamp, glass tube.
Ch.: 5^g $CaCO_3$, 10^{cc} HCl, 5^{cc} $Ca(OH)_2$ sol., candle.

1. Put 5^g $CaCO_3$ (marble in lumps) or Na_2CO_3 into a t.t., or a rec.; add 5^{cc} H_2O, and 5^{cc} HCl. Add more of the reagents as needed. Enough must be used to produce vigorous action. Equation.
2. Test the gas with a burning stick.
3. Attach a d.t. and collect one rec. of gas by down. disp., covering the rec. loosely with paper.
4. Pour a rec. of the gas down over a burning stick or candle, and note result.
5. Let the gas bubble from a d.t. into 5^{cc} $Ca(OH)_2$ sol. in another t.t. Look for a ppt. Equation. Let the action continue till the liquid clears. There is now excess of CO_2. $CO_2 + H_2O = ?$
6. When the sol. is clear, boil for a minute, and notice the reappearance of the ppt. $H_2CO_3 - CO_2 = ?$
7. Explain the phenomena.
8. Take 2^{cc} $Ca(OH)_2$ sol. in a clean t.t., and blow into it through a glass tube. What does the result show?
9. Put a little $Ca(OH)_2$ sol. in an e.d., and look for a scum after a few minutes. Explain.

55. STRUCTURE OF FLAME.

Ap.: lamp.
Ch.: candle.

1. Examine the structure of a Bunsen burner (unscrew the top), make a drawing to show the orifices, and state what use each subserves. Light the gas at the base for a minute.
2. Replace the top, and light the gas at the top of the burner.
3. Hold the flame in front of a dark object, examine the parts, make a drawing, give a brief description, and state the color of each part.
4. Put the flame in direct sunlight, and study the parts from its shadow, to confirm your results.
5. Make a careful examination of the parts and colors of a candle flame, and make a drawing to show them. Move it slightly in the air to show the outer flame. This is best seen in a dark room.



56. COMBUSTION OF FLAME.

Ap.: lamp, small d.t., Pt wire.
Ch.: stick, paper, wire gauze.

1. Light the gas of a Bunsen burner.
2. Put a stick across the base of the flame for an instant, and notice what parts are burned. Make a sketch.
3. Hold a stick just above the inner blue cone of the flame.
4. Press quickly down on the flame with a paper, remove before it burns, and notice the shape of the charred part. Sketch. Press down on the flame with a fine wire gauze, and observe by the glowing of the wire where the heat is most intense.
5. Test the heat of the *inner cone* with the end of a Pt wire. Notice that it glows when near the top, but not elsewhere in this cone.
6. Put one end of a small d.t. into the inner blue cone, and try to light the gas at the other end.
7. From the above state what takes place in each of the two chief parts of the flame.

57. LIGHT OF FLAME.

Ap.: lamp, e.d.
Ch.: $\frac{1}{4}^{s}$ fine charcoal.

1. Observe the light of a Bunsen flame, and its color.
2. Sprinkle a very little charcoal dust in the flame, and note any change of light or color.
3. Close the orifices at the base of the burner, and explain the change of light.
4. Hold an e.d. in the upper part of this closed flame for a minute, and notice deposit.
5. Now open the orifices and persistently try to burn off a little of the deposit from the e.d.
6. What is the cause of light in a flame?

58. TO CONFINE FLAME.

Ap.: lamp, 2 pieces wire gauze (10^{cm} square).

1. Light the gas and hold a fine wire gauze 3 or 4^{cm} above the burner. Why does it not burn above the wire?
2. Extinguish, then relight the gas above the gauze. Result.
3. Gradually lift the wire till the gas will not burn.
4. Again light the gas above the gauze, and hold another gauze above the flame, so as to confine it above and below.
5. From this experiment define *kindling point*, and state three conditions of combustion.

59. OXIDIZING AND REDUCING FLAMES.

Ap.: charcoal, blow-pipe, lamp.
Ch.: Pb (small bit); ½ˢ PbO.

1. Put a fragment of Pb, not larger than a pea, on a piece of charcoal, slightly hollowed out to hold it.
2. Insert the metallic tube in a Bunsen burner, and with a mouth blow-pipe blow the *oxidizing flame* strongly and steadily against the Pb for 4 or 5 minutes.
3. As you stop blowing, notice the yellow vapor that escapes from the pellet of Pb; also, as it cools, the yellow coating of PbO on the coal. Reaction.
4. Put ½ˢ PbO on a piece of charcoal. With the blow-pipe blow the *reducing flame* steadily against it for some time, or until a metallic pellet is obtained. What is it? Equation.
5. Extinguish the fire, if the coal still glows, by a jet of water.

60. TO MAKE CHLORINE AND TO BLEACH.

Ap.: 2 rec., t.t., paper.

Ch.: 5^g MnO_2, 10^{cc} HCl, Turkey-red cloth, green leaf, printing and writing.

1. Suspend in a rec. a small piece of wet Turkey-red cloth, also a dry piece; a piece of printed paper and a written one (both wet), and a leaf or colored flower.
2. Put into a t.t. 5^g MnO_2 and 10^{cc} HCl. Shake the mixture well.
3. Collect the gas by down. disp. in the rec. loosely covered with paper. Apply heat gently, and avoid inhaling the gas. Reaction.
4. Note the color of the gas, and its sp. gr. as compared with air. Observe when the rec. is filled, to avoid passing the gas into the room. If, accidentally, you breath any Cl, inhale the vapor of alcohol from a handkerchief; or NH_3 will answer.
5. Printer's ink contains C (a mineral pigment); writing ink, a vegetable coloring-matter. State the action of Cl on each.
6. State the theory of the chemistry of bleaching.

61. COMBUSTION IN CHLORINE.

Ap.: e.d., paper (unglazed).
Ch.: 3 rec. Cl, a little spirits of turpentine, a bit of Sb, As, or Cu (powdered), naphtha.

1. Charge 2 or 3 rec. with Cl by down. disp.
2. Dip some unglazed paper into oil of turpentine, $C_{10}H_{16}$, in an e.d.; warm it by holding near a flame for a minute, but do not set it on fire; then thrust it into a rec. of Cl. Explain the combustion. Reaction. Clean the rec. with naphtha or petroleum.
3. Sprinkle a pinch of finely powdered Sb, As, or Cu into a rec. of Cl. Reaction.

62. CHLORINE FROM SODIUM CHLORIDE.

Ap.: r.s., lamp, 2 t.t., d.t., rec.
Ch.: 1^g NaCl, 1^g MnO_2, 3^{cc} H_2SO_4.

1. Mix 1^g of fine NaCl and 1^g MnO_2, and add to them 2^{cc} H_2O and 3^{cc} H_2SO_4, in a t.t.
2. Pass a d.t. from this to a rec.
3. Heat, and notice the Cl gas.
4. $2\,NaCl + 3\,H_2SO_4 + MnO_2 = ?$ or
   $2\,NaCl + 2\,H_2SO_4 + MnO_2 = ?$

63. CHLORINE FROM BLEACHING-POWDER.

Ap.: small beaker (25 or 50^{cc}), large one (1000^{cc}).
Ch. : 5^{g} bleaching-powder, 10^{cc} H_2SO_4.

1. Put into a small beaker 5^{g} bleaching-powder, $CaCl_2 + Ca(ClO)_2$; set this in a large beaker, and hang in the latter the substance to be bleached.
2. Cover the large one with pasteboard, through which passes a thistle-tube into the smaller.
3. Pour through the thistle-tube 5^{cc} dilute H_2SO_4 (half water and half acid). Add more if needed.

64. CHLORINE WATER.

Ap.: 2 t.t.

Ch.: 3 or 4 crystals $KClO_3$, few drops HCl, 2^{cc} cochineal sol., 2^{cc} $K_2Cr_2O_7$ sol., Turkey red cloth.

1. Drop into a t.t. 3 or 4 crystals of $KClO_3$.
2. Add a few drops of HCl; hold in the flame for a minute, and when action begins add 5 or 10^{cc} H_2O. Cautiously take the odor.
3. To 2^{cc} indigo sol. in a t.t add a little Cl water. Is the color discharged?
4. To 2^{cc} cochineal sol. in a t.t. add a little Cl water. Is the solution bleached? Try also litmus sol.
5. To 2^{cc} $K_2Cr_2O_7$ sol. in a t.t. add a little Cl water. Is this bleached?
6. $K_2Cr_2O_7$ is a mineral pigment; cochineal is animal. Explain the results.
7. Try to bleach a piece of Turkey red cloth by putting it into some Cl water.

65. TO MAKE BROMINE.

Ap.: r.s., lamp, 2 t.t., d.t., rec.

Ch.: 1^g KBr, 1^g MnO, 5^{cc} H_2SO_4, 5^{cc} HCl, cloth, etc. (to bleach).

1. Mix 1^g KBr crystals, and 1^g MnO_2; transfer them to a t.t., and add 3^{cc} H_2SO_4.
2. Attach a d.t. and pass the other end of it to the bottom of a t.t. surrounded by a rec. of water.
3. Hang the apparatus on a r.s., and heat it slowly. Avoid getting Br vapor into the air of the room, as it is very irritating to the eyes.
   $MnO_2 + 2\ KBr + 3\ H_2SO_4 = ?$
   $MnO_2 + 2\ KBr + 2\ H_2SO_4 = ?$
4. Notice the color of the gas and the liquid; also the sp. gr. of the gas, by pouring some into a rec. Test the bleaching action of this on cloth.
5. Sift a bit of fine Sb, As, or Cu into the gas, and look for combustion. Clean the t.t. by heating HCl with the residue.

66. TO MAKE IODINE.

Ap. : lamp, 2 t.t., rec., e.d., st.r.
Ch. : 1^g KI, 1^g MnO_2, 1^g starch, paper, 3^{cc} H_2SO_4.

1. Generate I in this experiment like Br in the previous one, substituting KI for KBr. Reactions.
2. Put 1^g of fine starch into an e.d., add 2 or 3 drops of water, mix them; then pour on 5^{cc} of boiling water from a t.t., and stir the mixture. This makes starch paste.
3. Dip some strips of paper into the starch sol., and save for testing I. Hold one in the I vapor of this experiment, and note the color imparted to it. This is the test for I. What would be the test for starch?

67. SUBLIMATION OF IODINE.

Ap.: t.t., st.r.
Ch.: 4 or 5 crystals I.

1. Warm 1 or 2 crystals of I in a dry t.t. Notice the color of the vapor, and its sp. gr., by pouring some of it into the air.
2. Hold a st.r. half way down the t.t. while warming the tube. Look for a sublimate on the sides of the t.t. and on the rod, and observe the crystals of I.

68. SOLUTION OF IODINE.

Ap.: t.t.
Ch.: few crystals I, 5^{cc} C_2H_5OH, starch-papers.

1. Put 3 or 4 crystals of I into a t.t., and add 3 or 4^{cc} alcohol, C_2H_5OH.
2. Warm a minute and observe the solution. This is tincture of I. Add a drop of this with a st.r., to a drop of starch sol. shaken up with 10 or 15^{cc} H_2O. Observe the color. Boil it for a minute to see whether the color disappears. If not, too much I was added. Observe again when it is cool.
3. Try to dissolve 2 or 3 crystals of I in 2^{cc} H_2O in a clean t.t. Warm it.
4. See whether any is dissolved, by using the starch test as above.

69. TEST FOR IODINE.

Ap.: 2 t.t.
Ch.: 5^{cc} KI sol., starch sol., $KClO_3$, HCl.

1. Prepare 5^{cc} Cl water (Exp. 64) in a t.t.
2. Put into a clean t.t. 5^{cc} KI sol., and add a drop of starch sol. Shake them well together.
3. Now add a drop or two of Cl water, and notice the change of color. Explain and give reaction.

70. CRYSTALLIZATION OF SULPHUR.

Ap.: 1 beaker (25 or 50^{cc}), r.s., plate, asbestus, lamp, e.d.
Ch.: 15^{g} S (brimstone), 3^{cc} HNO_3.

1. Into a small beaker put 15^{g} S, and slowly melt it over a lamp. Note the color.
2. When melted, extinguish the light, and leave the beaker in position till it is cool enough not to break. Then remove it and watch the solidification of the S. When half solid, pour out the res. into an e.d. of water.
3. Look for crystals of S in the beaker.
4. Loosen the S by pouring round the edges a little HNO_3. Warm if necessary, when the mass may be removed by a thin knife-blade.

We put the sulphur in a crucible and heated until it was melted. Then after it had cooled we poured part into water and left the rest to cool. The part which was poured into the water became very much like amorphous sulphur. The part left in the crucible crystalized needle [illegible]

71. ALLOTROPY OF SULPHUR.

Ap.: lamp, e.d., t.t.
Ch.: 10^g S, 3^{cc} HNO_3.

1. Put 10^g S into a t.t. and slowly melt it. Notice the yellow color, and see that the liquid is very thin. It is now somewhat above 100°.
2. Heat it more strongly till it becomes black. Note it is now very thick and cannot be poured. It is about 200°.
3. Apply more heat till it grows thin again. It is above 300°.
4. Now heat to boiling (over 400°), note the color of the vapor and any sublimate on the t.t.
5. Pour the S into an e.d. of water. Knead it, and note its elasticity. See that it afterwards changes.
6. Clean the t.t. as before.

72. HYDROGEN SULPHIDE.

Ap.: 2 t.t., d.t., filter paper, funnel.

Ch.: 5^g FeS, 5^{cc} HCl or H_2SO_4, few drops $Pb(C_2H_3O_2)_2$ sol., Ag and Cu coins, lit.

1. Put into a rec. or a t.t. 5^g FeS, 10^{cc} H_2O and 5^{cc} HCl (or H_2SO_4). Equation.
2. Adjust a d.t. and pass the gas, for a minute or two, into 5^{cc} H_2O in another t.t. Have the bearings tight.
3. See whether this sol. is acid, alkaline, or neutral. Use both colors of lit.
4. With a st.r. put a drop of the H_2S sol. on Ag and Cu coins. Reactions.
5. Put a drop of $Pb(C_2H_3O_2)_2$ sol. on paper, and hold it in the vapor of H_2S. This is the characteristic test for H_2S.

73. HYDROGEN SULPHIDE AS A REAGENT.

Ap.: H_2S gen.
Ch.: Sol. $AgNO_3$, $Pb(NO_3)_2$, $Ba(NO_3)_2$, Na_2CO_3 (4^{cc} each), H_2S.

1. Pour 2^{cc} $AgNO_3$ sol. into a clean t.t., add 5^{cc} H_2O, shake it, and pass a little H_2S gas into it. Reaction. What is the ppt.?
2. Do the same with $Pb(NO_3)_2$ sol. Equation.
3. Do the same with $Ba(NO_3)_2$ sol. Why is there no equation?
4. Mix 2^{cc} $Pb(NO_3)_2$ sol. and 2^{cc} $Ba(NO_3)_2$ sol., 5^{cc} H_2O; shake them and pass H_2S gas into the liquid for two or three minutes. Which metal is ppd.? Equation.
5. Filter, and add to the filtrate 2 or 3^{cc} Na_2CO_3 sol. What is the ppt.? Equation.

74. SPONTANEOUS COMBUSTION OF PHOSPHORUS.

Ap.: e.d.
Ch.: 10^{cc} CS_2, paper, P (size of pea).

1. Into an e.d. put 10^{cc} CS_2, and drop into it 2 or 3 small pieces of P. This is enough for a class. Notice the odor of CS_2, and the solubility of P.
2. Dip a piece of unglazed paper into the sol., hold it in the air till it is dry, and look for any action. Explain fully.

75. COMBUSTION UNDER WATER.

Ap. : t.t., rec., thistle-tube.
Ch. : few crystals $KClO_3$, 3^{cc} H_2SO_4, P (usual size).

1. Put into a t.t. 4 or 5 crystals of $KClO_3$ and 3^{cc} H_2O, and a bit of P, half the size of a pea.
2. Rest the t.t. in a rec., then slowly add 2 or 3^{cc} H_2SO_4, through a thistle-tube watching for any combustion. Explain.

76. SUBLIMATION OF ARSENIC.

Ap.: i.t. (10^{cm} long, $\frac{1}{2}^{cm}$ diam.), lamp.
Ch.: As_2O_3 (very small bit), charcoal (fragment).

1. Prepare a small, pointed i.t., and put into the bottom a bit of As_2O_3, not larger that a grain of wheat.
2. Above this, at a little distance, insert a fragment of charcoal.
3. First heat the coal to redness, then heat the As_2O_3 so the fumes will go over the hot coal. Note the odor of the escaping As. Keep the coal hot.
4. Look for a sublimate (metallic mirror) above the coal.
5. Break the tube with a jet of water, and examine the sublimate. What is it? Equation.

77. TO MAKE SILICA FROM WATER GLASS.

Ap.: e.d., r.s., lamp, st.r.
Ch.: 5^{cc} Na_4SiO_4, 5^{cc} HCl, 10^{cc} NaOH sol.

1. Put into an e.d. 5^{cc} Na_4SiO_4 (or K_4SiO_4), and add the same volume of HCl. Describe the effect. $Na_4SiO_4 + 4\,HCl = ?$
2. Pour off any excess of HCl, and evaporate the residue over a flame or a water-bath. $H_4SiO_4 - 2\,H_2O = ?$
3. When the residue becomes white, cool it, add 10^{cc} H_2O, and stir it for a minute; then taste a drop, and pour off the water.
4. What is the residue? Crush a little with the fingers, and compare it with any substance you have seen before.
5. Remove any that adheres to the e.d. with strong NaOH sol., by boiling. SiO_2 is soluble in NaOH sol.

78. GUNPOWDER.

Ap.: lamp, brick.
Ch.: 4^g KNO_3 (or $NaNO_3$), $\frac{1}{2}^g$ S, $\frac{1}{2}^g$ charcoal.

1. Pulverize separately and very finely 4^g KNO_3 (or $NaNO_3$), $\frac{1}{2}^g$ S, $\frac{1}{2}^g$ charcoal, and mix them intimately on paper or in a mortar.
2. Pile the mixture on a brick, and apply a lighted match. $2\,KNO_3 + 3\,C + S = ?$
3. Remove the adhering product by soaking in water.

79. ACTION OF SOAP ON HARD WATER.

Ap.: t.t., e.d.
Ch.: 2^g hard soap, 10^{cc} $CaSO_4$ (or $MgSO_4$) sol.

1. Dissolve in a t.t., by boiling 1 or 2^g hard soap in 10 or 15^{cc} H_2O.
2. Add 10^{cc} of a clear solution of $CaSO_4$ or $MgSO_4$ (recently made), shake it, and look for a ppt. or any turbidity. An insoluble lime-soap has been formed.
3. Sodium $\left\{\begin{matrix}\text{stearate}\\ \text{palmitate}\\ \text{oleate}\end{matrix}\right\}$ + calcium sulphate = ?

   From this explain the action of hard water on soap.

80. COMBUSTION OF MAGNESIUM.

Ap.: lamp, forceps.
Ch.: Mg ribbon (3^{cm}).

1. Examine a piece of Mg ribbon, and describe, noting any tarnish.
2. With the forceps hold it in a flame till it begins to burn. Notice the color and intensity of the light.
3. Observe the product, and name it. Equation.

81. TO OXIDIZE FERROUS TO FERRIC SALTS (Fe^{II} to Fe^{IV}).

Ap.: 2 t.t.
Ch.: 10cc $FeSO_4$ sol., 5cc NaOH or NH_4OH, 1cc HNO_3.

1. Into each of 2 t.t. put 5cc $FeSO_4$ sol. (recently prepared).
2. To one of these add 1cc HNO_3, and boil a minute.
3. Add to each 5cc NaOH sol. or NH_4OH. Reactions.
4. Explain the oxidation and the difference of colors, and see whether either hydrate tends to change to the other by standing. $FeSO_4$ has been oxidized to $Fe_2(SO_4)_3$.

82. TO REDUCE FERRIC TO FERROUS SALTS (Fe^{IV} to Fe^{II}).

Ap.: 4 t.t., d.t.
Ch. : 5cc $FeSO_4$ sol., HNO_3, NH_4OH, 2g Cu, 5cc H_2SO_4.

1. Oxidize 5cc $FeSO_4$ sol. with 1cc HNO_3, by boiling, as in Exp. 81, and dilute it with its volume of water.
2. Pour a little of this into another t.t., add to it NH_4OH, and note the color of the ppt.
3. Pass SO_2 gas from a gen. (Cu and H_2SO_4 heated in a t.t.), into the other portion for a few minutes.
4. Next add NH_4OH, and note the color of the ppt. Compare it with the previous product. $Fe_2(SO_4)_3$ has been reduced to $FeSO_4$, if the action continued long enough.

83. TO MAKE LEAD SALTS.

Ap.: 3 t.t.

Ch.: 55^{cc} $Pb(NO_3)_2$ sol., 5^{cc} sol. of each of these: $(NH_4)_2S$, K_2CrO_4, H_2SO_4, KI, KBr, NaCl, NaOH, Na_2SO_3, Na_2CO_3, KCN, $K_4Fe(CN)_6$.

Add 5^{cc} $Pb(NO_3)_2$ sol. to each of the following in a clean t.t. Give the color of each product, name it, and write the reaction for its production. State whether a ppt. is produced. Tubes may be cleaned by the use of water and a swab.

(*a*) 5^{cc} $(NH_4)_2S$.
(*b*) 5^{cc} K_2CrO_4 sol.
(*c*) 5^{cc} H_2SO_4.
(*d*) 5^{cc} KI sol.
(*e*) 5^{cc} KBr sol.
(*f*) 5^{cc} NaCl sol.
(*g*) 5^{cc} NaOH sol.
(*h*) 5^{cc} Na_2SO_3 sol.
(*i*) 5^{cc} Na_2CO_3 sol.
(*j*) 5^{cc} KCN sol.
(*k*) 5^{cc} $K_4Fe(CN)_6$ sol.

84. TO ILLUSTRATE PHOTOGRAPHY.

Ap.: 2 t.t., filter paper, funnel, st.r., rec.
Ch.: 2^{cc} $AgNO_3$ sol., 4^{cc} NaCl sol., 10^{cc} $Na_2S_2O_3$ sol.

1. Put into each of 2 t.t. 10^{cc} H_2O, 1^{cc} $AgNO_3$ sol., and 2^{cc} NaCl sol.; shake, and notice the color. What is the product? Reaction.
2. Filter one of them, and wash the residue well with water, by pouring water on it, and allowing the water to run through the filter. Reject the wash-water. Then open the filter paper, and expose the residue to direct sunlight. Presently stir it, and observe the change of color produced by the light. $2\,AgCl - Cl = ?$
3. Add to the other portion 5^{cc} $Na_2S_2O_3$ sol. Shake it, and notice whether the ppt. dissolves. If not, add more *hypo*.

85. TO ILLUSTRATE PHOTOGRAPHY.

Ap.: 2 t.t., filter paper, funnel.
Ch.: 2^{cc} $AgNO_3$ sol., 4^{cc} KBr sol., 10^{cc} $Na_2S_2O_3$ sol.

1. Put into each of 2 t.t. 10^{cc} H_2O, 1^{cc} $AgNO_3$ sol., and 2^{cc} KBr sol. Shake, and filter the contents of one, and wash the residue. Reaction. Expose to direct sunlight, and observe the change of color. $2\,AgBr - Br = ?$
2. To the other add $Na_2S_2O_3$ sol. till the ppt. dissolves.

86. DESTRUCTIVE DISTILLATION OF WOOD.

Ap.: lamp, plate, i.t. (10^{cm} long, 1 or 1½^{cm} diam.).
Ch.: wood shavings.

1. Half fill an i.t. with wood shavings closely packed.
2. Hold it steadily over a lamp to heat it, meantime trying to ignite the escaping gas. Note the color of the flame, and see whether any soot is deposited on an e.d. held in the burning gas.
3. Break, and examine the tube for a tarry residue, and for coal.
4. Put the coal on an iron plate and bring a Bunsen flame in contact with it, noting whether it burns with a flame, or only glows. Only gas burns with flame.
5. Write no reactions, but state how many and what products you observed in this experiment.

87. ILLUMINATING GAS.

Ap.: i.t. (10^{cm} long, 1 or 1½^{cm} diam.), lamp, plate.
Ch.: 5^{g} cannel coal (granular masses).

1. Fill an i.t. ⅓ full of cannel (or bituminous) coal.
2. Perform this experiment like the previous one, apply the same tests throughout, and notice and describe all the products. Heat strongly and as long as any gas separates.

88. ALCOHOL.

Two pupils may work together.

Ap.: apparatus for distilling, t.t., d.t., flask.
Ch. : 20cc molasses, half a cake of yeast.

1. Put 20cc molasses into a flask (of 200cc), fill it with water to the neck, and put in half a cake of yeast.
2. Fit to it a d.t., and pass the end into a t.t. holding some clear lime water. Leave it in a warm place for two or three days.
3. Look for any turbidity in the lime water, and account for it. See whether the liquid in the flask is sweet.
4. Attach the flask to an apparatus for distilling water, and pass over not more than one-fifth of the liquid by distillation.
5. Taste and smell the distillate. Re-distil it if desired, passing over not more than half of it.

89. VEGETABLE PARCHMENT.

Ap.: e.d.
Ch.: 12^{cc} H_2SO_4, filter papers.

1. Pour into an e.d. 5^{cc} H_2O, add 12^{cc} H_2SO_4 (measure each), and stir the mixture.
2. *When it becomes cold*, dip a strip of unglazed paper (filter paper) into the liquid, and leave 15 seconds. One end of the paper should be out of the liquid, in order to remove it quickly.
3. At once rinse it thoroughly with water, then let it dry.
4. If the fibre is not toughened, try again, using new paper and varying the time a little.

90. TO SEPARATE SILVER FROM COPPER.

Ap.: 2 t.t., funnel, filter papers, rec.
Ch.: 5^{cc} sol. $AgNO_3$ and 5^{cc} sol. $Cu(NO_3)_2$, 5^{cc} HCl, H_2S gen.

1. Pour into a t.t. 5^{cc} $AgNO_3$ sol. and 5^{cc} $Cu(NO_3)_2$ sol. Shake them together.
2. Add HCl till no more ppt. continues to form, then pour it on a filter. Save the filtrate. Reaction for $AgNO_3$. $Cu(NO_3)_2$ is unchanged.
3. See whether all the Ag is ppd. by adding 2 or 3 drops of HCl to the filtrate. If a ppt. occurs, add more, and filter again.
4. Note what the *residue* is, and what the *filtrate* contains.
5. Pass into the filtrate some H_2S gas. (Exp. 72.) Reaction. This ppts. CuS.
6. Filter. What is the residue? What metals have been separated?

91. ANALYSIS OF A SILVER COIN.

Ap.: e.d., lamp, H_2S gen.
Ch.: ten-cent coin, 5^{cc} HNO_3, 20^{cc} HCl, 5^{g} FeS.

1. Put a ten-cent Ag coin into an e.d., and pour over it a mixture of 5^{cc} HNO_3 and 10^{cc} H_2O. Warm it till all or nearly all has dissolved.
2. Remove any that is undissolved, and pour the liquid into a t.t. Add HCl as long as a ppt. continues to form, then filter. AgCl is the residue. Reaction.
3. Add a drop or two of HCl to the filtrate, and, if a ppt. falls, add more, and filter again, to remove all the Ag.
4. Evaporate the filtrate to a few drops in an e.d. (to remove any free HNO_3), then add H_2O and pass H_2S gas into the filtrate so long as a ppt. forms. This is CuS. Reaction. Filter. The coin is thus found to contain Ag, and Cu. This experiment is an example of qualitative analysis.

92. ANALYSIS OF TIN-FOIL.

Ap.: 3 or 4 t.t., lamp.

Ch.: HNO_3, HCl, H_2SO_4, K_2CrO_4 sol., $(NH_4)_2S$, HNa_2PO_4 sol., tin-foil.

1. Cover a small piece of tin-foil in an e.d. with 1 part HNO_3 to 5 parts water, enough to dissolve it, or nearly so. Warm the mixture.
2. Filter if necessary, and add its bulk of H_2O to the filtrate, then slowly add HCl till no more ppt., $PbCl_2$, falls. Filter and set aside the filtrate (for 4). Reaction.
3. Pour boiling water on the residue, and let it run through into a clean t.t. If it is not clear, boil a minute, then divide it into two parts. To one add a little K_2CrO_4 sol.; to the other add H_2SO_4. The ppts. are $PbCrO_4$ and $PbSO_4$. These prove the presence of Pb. Reactions.
4. Evaporate in an e.d. the filtrate (from 2) to a few drops (to remove free acid), then add some H_2O and saturate it with H_2S: black ppt. is SnS. To prove it is Sn, filter, pour on res. a very little boiling dil. HCl, which dissolves SnS as $SnCl_2$. Then add $HgCl_2$ sol.: white ppt. is HgCl, gray is Hg, either of which shows presence of Sn.

93. ANALYSIS OF FIRST GROUP METALS.

Pb, Hg(ous), Ag.

Solutions: $Pb(NO_3)_2$, $HgNO_3$, $AgNO_3$.
Reagents: dil. HCl, $K_2Cr_2O_7$ sol., NH_4OH, HNO_3.

1. To 5^{cc} of a mixture of the above solutions add dil. HCl till the ppt. does not increase, then shake: ppt. contains $PbCl_2$, HgCl, AgCl. Filter and reject the filtrate.
2. Wash the res. several times with cold water and reject the washings. Then add 10^{cc} boiling H_2O to the res.: filtrate contains $PbCl_2$; res. is HgCl and AgCl.
3. Add to filtrate $K_2Cr_2O_7$ sol.: yellow ppt. is $PbCrO_4$.
4. Pour on the res. (from 2) NH_4OH: sol. contains $(NH_3)_2(AgCl)_2$; black res. is NH_2Hg_2Cl.
5. To filtrate add HNO_3: ppt. is AgCl. The three metals have thus been separated. Reactions may be omitted in the analyses.

94. ANALYSIS OF SECOND GROUP METALS, A.

Hg(ic), Pb, Bi, Cd, Cu.

Solutions: $Hg(NO_3)_2$, $Pb(NO_3)_2$, $Bi(NO_3)_3$, $Cd(NO_3)_2$, $Cu(NO_3)_2$.

Reagents: H_2S, HNO_3, dil. HNO_3, HCl, dil. H_2SO_4, $SnCl_2$ sol., NH_4OH, KCN sol.

1. Into 5^{cc} of the sol. pass H_2S gas to sat.: ppt. is HgS, PbS, Bi_2S_3, CdS, CuS. Filter, then wash the res. repeatedly till the wash-water gives no ppt. when a drop of $AgNO_3$ sol. is added.
2. Open the filter paper and remove the res. with a spatula to an e.d. Cover it well with dil. HNO_3, and boil it a minute or two: insoluble res. is HgS and S (S is set free); sol. contains $Pb(NO_3)_2$, $Bi(NO_3)_3$, $Cd(NO_3)_2$, $Cu(NO_3)_2$. Decant it upon a filter, leaving the res. in the e.d.
3. Cover the res. with aqua regia, newly made, and stir it: sol. contains $HgCl_2$; yellow or black insol. res. is S. Filter and add to the filtrate $SnCl_2$ sol.: white ppt. is HgCl; gray ppt. is Hg.
4. To filtrate (from 2), add a very little dil. H_2SO_4, shake, and let it stand a few minutes: white ppt. is $PbSO_4$. Filter.
5. Add to filtrate NH_4OH: flaky white ppt. is $Bi(OH)_3$. Filter. Filtrate contains $Cd(OH)_2$ and $Cu(OH)_2$; blue color indicates Cu.
6. Add to filtrate KCN sol. till the blue color disappears, then sat. with H_2S: yellow ppt. is CdS; sol. contains $(KCN)_2Cu(CN)_2$.
7. Filter and acidify filtrate with HCl: black ppt. is CuS.

95. ANALYSIS OF SECOND GROUP METALS, B.

As, Sn, Sb.

Solutions: Na_3AsO_3, $SnCl_2$, $SbCl_3$ (dissolved in H_2O and HCl).

Reagents: $H_2S(NH_4)_2CO_3$ sol., HCl, $KClO_3$, Pt, Zn, $HgCl_2$ sol., HNO_3, $H_2C_4H_4O_6$ sol.

1. Sat. 5^{cc} of the sol. with H_2S: ppt. is As_2S_3, SnS, Sb_2S_3. Filter and wash.
2. Add to the res. in an e.d. $(NH_4)_2CO_3$ sol. and stir it well: sol. contains $(NH_4)_3AsO_3$ and $(NH_4)_3AsS_3$. Filter and wash.
3. Acidify filtrate with HCl: yellow ppt. is As_2S_3.
4. To res. (from 2), in an e.d., add a little HCl (avoid excess) and two or three crystals of $KClO_3$, then boil: sol. contains $SnCl_2$ and $SbCl_3$.
5. Dilute the sol. and put in a piece of Pt foil and a piece of Zn in contact: white ppt. on the metals is Sn, black is Sb; sol. contains $ZnCl_2$.
6. When action has nearly ceased, pour off the liquid and carefully wash the metals, then add a little HCl: sol. contains $SnCl_2$ (and $ZnCl_2$).
7. Decant upon a filter and add to the filtrate $HgCl_2$ sol.: white ppt. is HgCl, gray is Hg.
8. Carefully wash the black res. in the e.d., then add a little $H_2C_4H_4O_6$ sol. with a few drops of HNO_3: sol. contains Sb_2O_3 and $(SbO)_2C_4H_4O_6$. Filter from impurities.
9. Treat filtrate with H_2S: orange ppt. is Sb_2S_3.

96. ANALYSIS OF THIRD GROUP METALS.

Fe, Al, Cr.

Solutions: $FeSO_4$, $K_2Al_2(SO_4)_4$, $K_2Cr_2O_7$.
Reagents: NH_4OH, HNO_3, HCl, $KClO_3$, $HC_2H_3O_2$, C_2H_5OH, NaOH sol., $Pb(C_2H_3O_2)_2$ sol.

1. To 5^{cc} of the sol. add a few drops of HNO_3 and boil for an instant: yellow color shows oxidation of $FeSO_4$ to $Fe_2(SO_4)_3$.
2. Add a few drops of HCl and of C_2H_5OH and carefully boil a minute or two, then leave till chemical action ceases: green color shows $K_2Cr_2O_7$ is reduced to Cr_2Cl_6.
3. Alkalize the sol. with NH_4OH: ppt. is $Fe_2(OH)_6$, $Al_2(OH)_6$, $Cr_2(OH)_6$. Filter and wash thoroughly.
4. Dissolve the res. in a little HNO_3: sol. contains $Fe_2(NO_3)_6$, $Al_2(NO_3)_6$, $Cr_2(NO_3)_6$.
5. Boil the filtrate in a t.t. with a few crystals of $KClO_3$ until it is distinctly red, adding H_2O as it evaporates; shake the t.t vigorously while boiling: sol. contains $Fe_2(NO_3)_6$, $Al_2(NO_3)_6$, $K_2Cr_2O_7$. ($Cr_2(NO_3)_6$ has been oxidized to $K_2Cr_2O_7$, which prevents its ppn. in 6 and 7.)
6. Add excess of NaOH sol.: reddish ppt. is $Fe_2(OH)_6$; sol. contains $Na_2Al_2O_4$, Na_2CrO_4. Filter.
7. Acidify filtrate with HCl, then alkalize with NH_4OH: white flaky ppt., which rises to the surface after standing, is $Al_2(OH)_6$. (H_4SiO_4, contained in the NaOH, may be ppd. here, but this on standing sinks to the bottom.) Filter.
8. Acidify filtrate with $HC_2H_3O_2$; add $Pb(C_2H_3O_2)_2$ sol.: yellow or reddish ppt. is $PbCrO_4$.

97. ANALYSIS OF FOURTH GROUP METALS.

Co, Ni, Mn, Zn.

Solutions: $CoCl_2$, $NiCl_2$, $MnCl_2$, $ZnCl_2$.
Reagents: $(NH_4)_2S$, dil. HCl, HCl, HNO_3, $HC_2H_3O_2$, NaOH sol., KNO_2 sol.

1. To 5^{cc} of the sol. add $(NH_4)_2S$, shake and warm it, without boiling: ppt. is CoS, NiS, MnS, ZnS. Filter, then pour on the res. a few drops of $(NH_4)_2S$ (to prevent oxidation), and at once wash with hot water two or three times.
2. Transfer the res. to an e.d., pour on it dil. HCl, stir it well, then filter and wash: sol. contains $MnCl_2$ and $ZnCl_2$; res. is CoS and NiS.
3. Remove res. to an e.d. and dissolve in a little aqua regia: sol. contains $CoCl_2$ and $NiCl_2$. Filter if necessary.
4. Add to the filtrate excess of NaOH sol.: ppt. is $Co(OH)_2$ and $Ni(OH)_2$. Filter.
5. Pour on res. $HC_2H_3O_2$: sol. contains $Co(C_2H_3O_2)_2$ and $Ni(C_2H_3O_2)_2$.
6. Add to the sol. a little KNO_2 sol.: yellow ppt. (complete only after several hours) is $K_6Co_2(NO_2)_{12}$.
7. Filter and add to filtrate excess of NaOH sol.; light flaky ppt. is $Ni(OH)_2$.
8. Boil filtrate (from 2) to expel all H_2S, add excess of NaOH sol., shake well and warm it: brown ppt. is $Mn(OH)_2$; sol. contains Na_2ZnO_2. (Unless excess of strong NaOH sol. is added, white $Zn(OH)_2$ is ppd.
9. Filter, and acidify filtrate with $HC_2H_3O_2$: sol. contains $Zn(C_2H_3O_2)_2$.
10. Add $(NH_4)_2S$: ppt. (white if pure) is ZnS.

98. ANALYSIS OF FIFTH GROUP METALS.

Ba, Sr, Ca, Mg.

Solutions: $BaCl_2$, $SrCl_2$, $CaCl_2$, $MgCl_2$.
Reagents: NH_4OH, NH_4Cl sol., $(NH_4)_2CO_3$ sol., $(NH_4)_2C_2O_4$ sol., $HC_2H_3O_2$, HNa_2PO_4 sol., $K_2Cr_2O_7$ sol., $(NH_4)_2SO_4$ sol.

1. To 5cc of the sol. add a little NH_4Cl sol. and NH_4OH, then excess of $(NH_4)_2CO_3$ sol. and warm it: ppt. is $BaCO_3$, $SrCO_3$, $CaCO_3$; sol. contains $MgCO_3(NH_4)_2CO_3$. Filter (save filtrate for 6) and wash with hot water.
2. Pour on the ppt. $HC_2H_3O_2$: sol. contains $Ba(C_2H_3O_2)_2$, $Sr(C_2H_3O_2)_2$, $Ca(C_2H_3O_2)_2$.
3. Add $K_2Cr_2O_7$ sol.: yellow ppt. is $BaCrO_4$.
4. Filter and add to filtrate $(NH_4)_2SO_4$ sol. and shake it well: white ppt. is $SrSO_4$. (Unless $(NH_4)_2SO_4$ sol. is very dilute, $CaSO_4$ will be ppd. here.)
5. Filter and add to filtrate NH_4OH and $(NH_4)_2C_2O_4$ sol.: white ppt. is CaC_2O_4.
6. To filtrate (from 1) add HNa_2PO_4 sol.: white ppt. is NH_4MgPO_4.

99. SEPARATION OF GROUPS I.–V.

Solutions: Any mixtures of Groups I.–V. that do not form a ppt.

Reagents: HCl, H_2S, $(NH_4)_2S$, NH_4Cl sol., NH_4OH.

1. To 5^{cc} of the sol. add dil. HCl: ppt. contains Group I. Filter, wash, and analyze this by Group I. (Test filtrate with HCl to be sure all is ppd.) Filtrate contains Groups II.–V.
2. Saturate the filtrate with H_2S: ppt. contains Group II., A and B. Filtrate contains Groups III.–V. Filter. (To separate A from B, wash the ppt., then warm it in an e.d. with $(NH_4)_2S$. Filter: res. contains II., A; filtrate contains II., B. Analyze by respective groups.)
3. To filtrate (after oxidizing Fe and reducing Cr by Group III.), add NH_4Cl and NH_4OH: ppt. contains Group III.; filter, wash, and analyze by Group III. Filtrate contains Groups IV., V.
4. To filtrate, add $(NH_4)_2S$: ppt. contains Group IV.; filter, wash, and analyze by Group IV. Filtrate contains Group V.
5. Analyze filtrate by Group V.

100. TESTS FOR ACID RADICALS.

Cl, Br, I, S, NO_3, SO_4, CO_3, PO_4.

Solutions: $NaCl$, KBr, KI, Na_2S, $NaNO_3$, Na_2SO_4, Na_2CO_3, HNa_2PO_4.

Reagents: $AgNO_3$ sol., NH_4OH, HCl, $KClO_3$, CS_2, $Pb(C_2H_3O_2)_2$ sol., H_2SO_4, $FeSO_4$ sol., $BaCl_2$ sol., $Ca(OH)_2$ sol., NH_4Cl sol., $MgSO_4$ sol.

1. *Chlorides*, Cl. To 5cc NaCl sol. add a few drops $AgNO_3$ sol.: white ppt. is AgCl, soluble in NH_4OH.
2. *Bromides*, Br. To 5cc KBr sol. add 2 or 3 drops of CS_2, then dil. chlorine water, a few drops at a time, and shake well: the CS_2 at the bottom is yellow or reddish.
3. *Iodides*, I. To 5cc KI sol. add 2 or 3 drops of CS_2, then a very little dilute chlorine water, and shake it: the CS_2 at the bottom is violet.
4. *Sulphides*, S. To 5cc Na_2S sol. add HCl; put a drop of $Pb(C_2H_3O_2)_2$ sol. on paper and hold it over the Na_2S sol. as it is heated: black ppt. of metallic luster is PbS.
5. *Nitrates*, NO_3. Mix 5cc $NaNO_3$ sol. with a little H_2SO_4 and cool it; then pour down the side of the tube a little $FeSO_4$ sol.: brown or red ring is $(FeSO_4)_2NO$.
6. *Sulphates*, SO_4. Add to 5cc Na_2SO_4 sol. $BaCl_2$ sol.: white ppt. is $BaSO_4$, insoluble in HCl.
7. *Carbonates*, CO_3. To 5cc Na_2CO_3 sol. add HCl and pass the gas into $Ca(OH)_2$ sol.: white ppt. is $CaCO_3$, soluble in excess.
8. *Phosphates*, PO_4. To 5cc HNa_2PO_4 sol. add NH_4Cl sol., NH_4OH and $MgCl_2$ sol.: white ppt. is $MgNH_4PO_4$.

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